

JANUARY 1956



VOL. 48 • NO. 1

# Journal

AMERICAN  
WATER WORKS  
ASSOCIATION

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**AWWA, 1881-1956**

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**Corrosion in Boilers**

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**Demineralizers**

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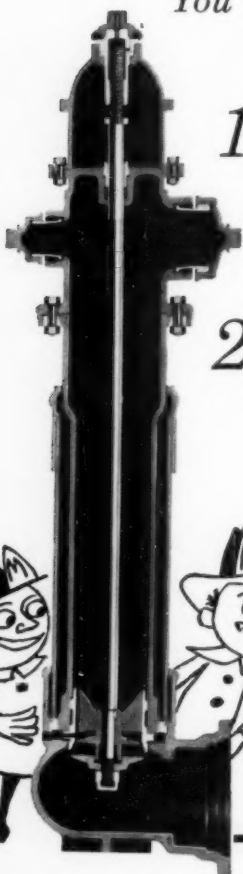
**Decker, Hoppert, Byerrum**

**Maintenance Painting Procedures**

**Kimmel**

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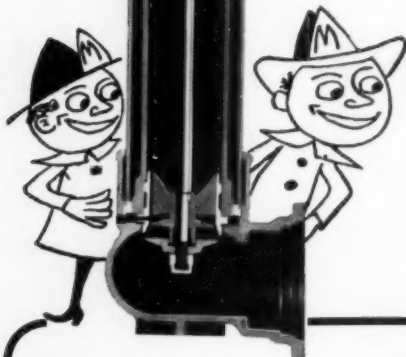
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Available for mechanical  
joint connections

# Journal

## AMERICAN WATER WORKS ASSOCIATION

521 FIFTH AVE., NEW YORK 17, N.Y.

Phone: MUrray Hill 2-4515

January 1956

Vol. 48 • No. 1

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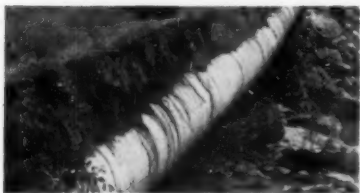
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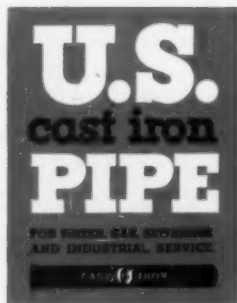
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All reservations will be cleared through the AWWA office. The nine official hotels have agreed to accept no reservations for the 1956 Conference except as they are requested on the standard form, through the AWWA.



## *Coming Meetings*

**AWWA SECTIONS**

**Jan. 17**—New York Section Mid-winter Luncheon, at Park Sheraton Hotel, New York. Secretary, Kimball Blanchard, Rensselaer Valve Co., 11 W. 42nd St., New York 36.

**Feb. 8-10**—Indiana Section, at Lincoln Hotel, Indianapolis. Secretary, R. J. Becker, Indianapolis Water Co., 113 Monument Circle, Indianapolis 6.

**Feb. 14**—New Jersey Section Winter Luncheon, at Essex House, Newark. Secretary, C. B. Tygert, Box 178, Newark 1.

**Mar. 18-21**—Southeastern Section, at Bon Air Hotel, Augusta, Ga. Secretary, N. M. deJarnette, Georgia Dept. of Public Health, 245 State Office Bldg., Atlanta 3.

**Mar. 21-23**—Illinois Section, at LaSalle Hotel, Chicago. Secretary, D. W. Johnson, Cast Iron Pipe Research Assn., 122 S. Michigan Ave., Chicago 3.

**Apr. 3-5**—Pennsylvania Section, at Bellevue-Stratford Hotel, Philadelphia. Secretary, L. S. Morgan, State Dept. of Health, Greensburg.

**Apr. 4-6**—Kansas Section, at Jayhawk Hotel, Topeka. Secretary, H. W. Badley, Neptune Meter Co., 119 W. Cloud St., Salina.

**Apr. 5-7**—Arizona section, at Buena Vista Hotel, Safford. Secretary, Quentin M. Mees, Arizona Sewage & Water Works Assn., 721 N. Olsen Ave., Tucson.

**Apr. 6-7**—Montana Section, at Murray Hotel, Livingston. Secretary, A. W. Clarkson, State Board of Health, Helena.

(Continued on page 8)

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water meter  
you can buy is*  
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**SOUTH BOSTON, MASS.**

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**Coming Meetings**

(Continued from page 6)

**Apr. 11-13**—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, J. E. Olsson, Fulton & Cramer, 922 Trust Bldg., Lincoln.

**Apr. 18-20**—New York Section, at Hotel Utica, Utica. Secretary, Kimball Blanchard, Rensselaer Valve Co., 11 W. 42nd St., New York 36.

**Apr. 23-25**—Canadian Section, at Hotel London, London, Ont. Secretary, A. E. Berry, 72 Grenville St., Toronto, Ont.

**Apr. 26-28**—Pacific Northwest Section, at Empress Hotel, Victoria, B.C. Secretary, F. D. Jones, Room 305, City Hall, Spokane, Wash.

**OTHER ORGANIZATIONS**

**Jan. 26-27**—Conference on Water Reclamation, Berkeley, Calif., sponsored by Sanitary Engineering Research Lab., University of California.

**Feb. 13-17**—American Society of Civil Engineers National Winter Convention, Baker Hotel, Dallas, Tex.

**Feb. 13-18**—Symposium on Winter Concreting Theory and Practice, International Union of Testing & Research Labs. for Materials & Structures

(RILEM), Copenhagen, Denmark. Organizing Secy., RILEM Symposium 1956, c/o Danish National Inst. of Building Research, 20 Borgergade, Copenhagen, K, Denmark.

**Feb. 26-29**—American Institute of Chemical Engineers, Statler Hotel, Los Angeles, Calif.

**Feb. 27-Mar. 2**—American Society for Testing Materials, Hotel Statler, Buffalo, N.Y.

**Mar. 19-20**—Steel Founders Society of America, Drake Hotel, Chicago, Ill.

**Apr. 3-5**—Short Course on Corrosion, at University of Oklahoma Extension Study Center, Norman, Okla.

**Apr. 5-6**—Southern Municipal and Industrial Waste Conference, Chapel Hill, N.C. For information write D. A. Okun, Dept. of Sanitary Engineering, University of North Carolina, Chapel Hill, N.C.

**Jun. 17-23**—World Power Conference, Vienna, Austria. Oesterreichisches Nationalkomitee der Weltkraftkonferenz, Vienna I, Schwarzenbergplatz 1.

**Oct. 8-11**—Federation of Sewage & Industrial Wastes Assns., Statler Hotel, Los Angeles, Calif.



## Here's how users feel about F&P Chlorination



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Mr. Marshall Houghn, Assistant Superintendent in charge of the City Water Division Plant in Columbus, Ohio is one of hundreds of satisfied users of Fischer & Porter Chlorinators. No other chlorinator has gained so many friends so fast. No other chlorinator has proven itself by delivering continuous satisfactory service, year in and year out, with the lowest maintenance costs ever recorded. Write now for information on the complete F & P line of water and sewage chlorination equipment. A postcard will do. No obligation, of course. Fischer & Porter Co. 916 Fischer Road, Hatboro, Pa.





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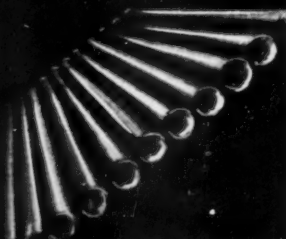
the A.W.W.A., A.S.T.M. and Federal specifications for asbestos-cement pipe.

Free Booklet—"Mains Without Maintenance" gives valuable specifications and reference data for "Century" Pipe. Write for it today.

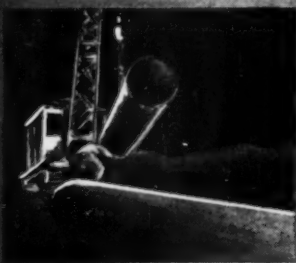
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230 (AWWA) Enamel for water lines



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CA-50 for metal exposed to corrosive atmospheres, acid, salt, and alkaline, and against corrosion caused by condensation moisture.

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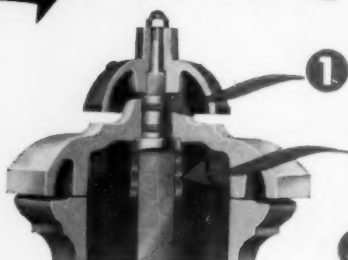


**NEW**

A. W. W. A.

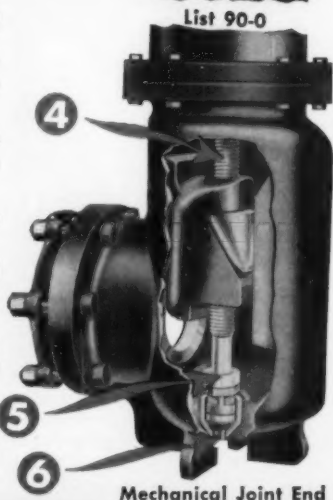
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**NO Stem Breakage!**



List 90-0

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- ② **POP-OFF SLEEVE COUPLING** releases hydrant head from stem in event of traffic damage.
- ③ **GROUND LINE FLANGE** eliminates digging.
- ④ **90,000 TENSILE STRENGTH** Rolled Everdur threaded stem section completely eliminates stem failure.
- ⑤ **NO FLOODING.** Closed hydrant remains locked—even in event of traffic accident.
- ⑥ **NO FREEZING.** Positive drip action, at extreme bottom, assures complete drainage.



Mechanical Joint End

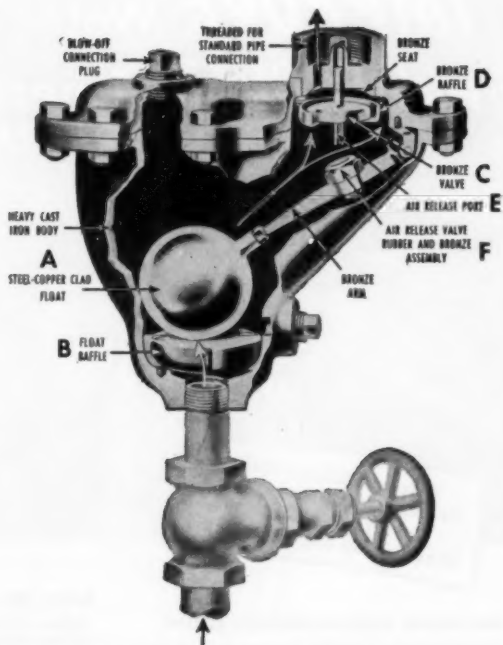
## THE LUDLOW VALVE

ESTB. 1861

MFG. CO. INC. TROY · N. Y.

CANADIAN LUDLOW VALVE MFG. CO., LTD., MONTREAL

# Rensselaer Combined Air and Vacuum AND Air Release VALVES



This Rensselaer valve is used to allow air to escape while the pipe is being filled with water; to allow air to flow into the pipe when it is being emptied of water and to allow accumulated air under pressure to escape at high points of the line.

It is used extensively for water mains, turbine pump discharge, bowls of booster pumps, air tanks and sand traps.

This valve will positively close under low water head, cannot blow shut and allows full and clear passage of air.

It is a combination vent, vacuum and pressure air valve, with all parts built for long and satisfactory service.

It is available in simplified form for air release only. Ask for bulletin No. F.

106C

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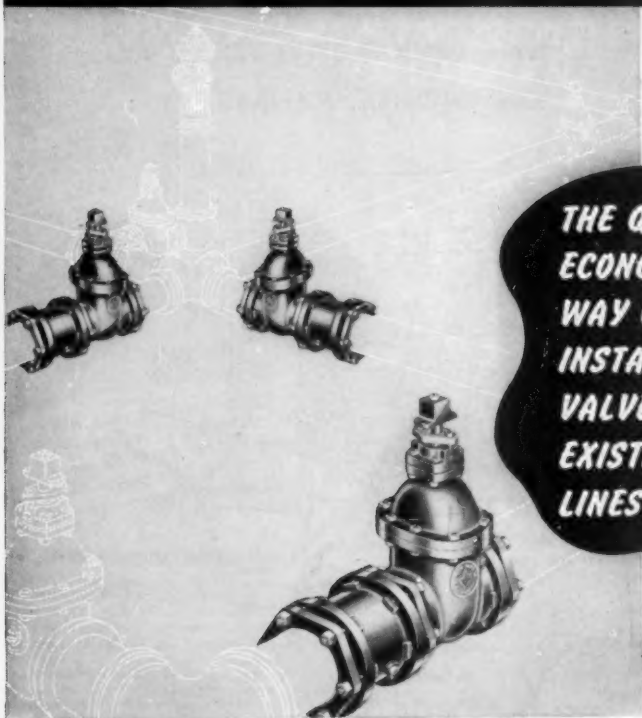
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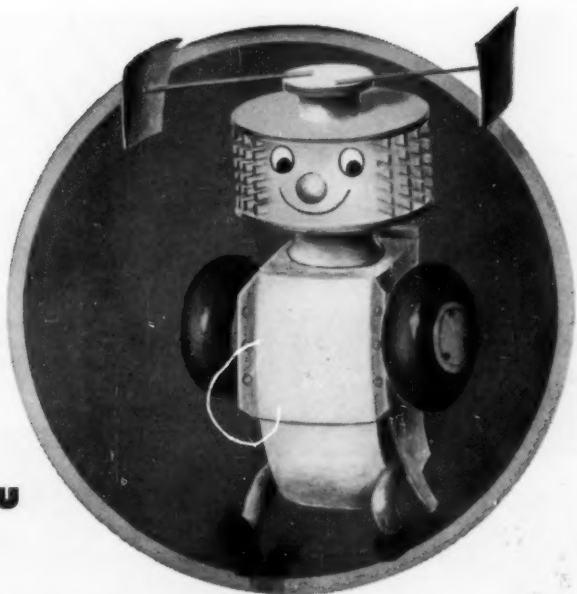


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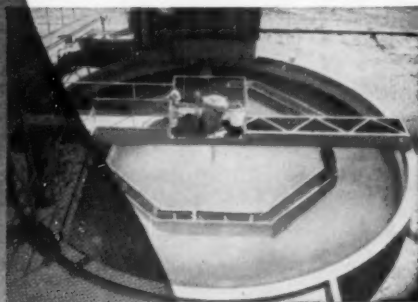
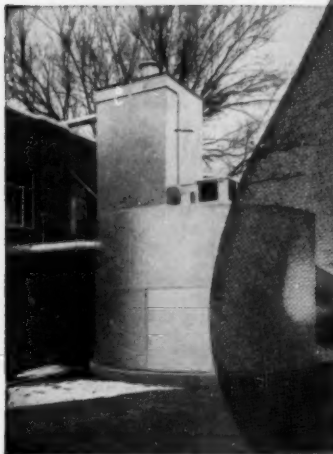
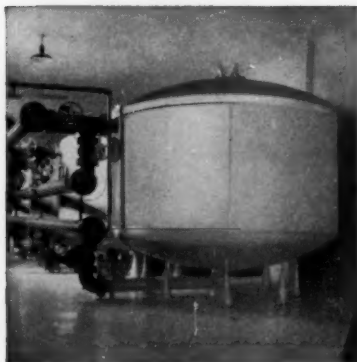
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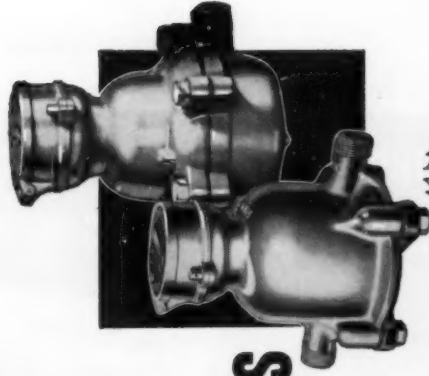


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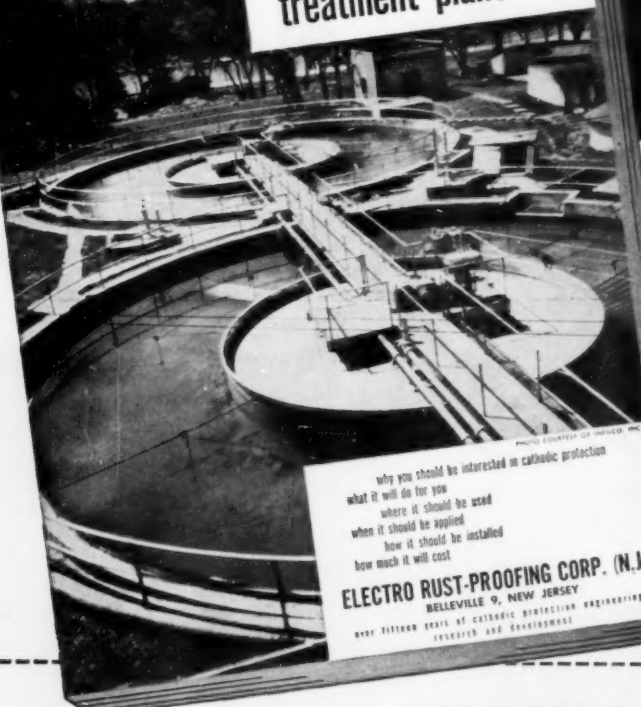
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E-33



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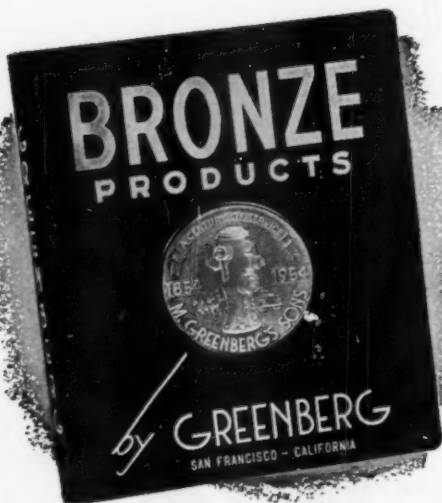
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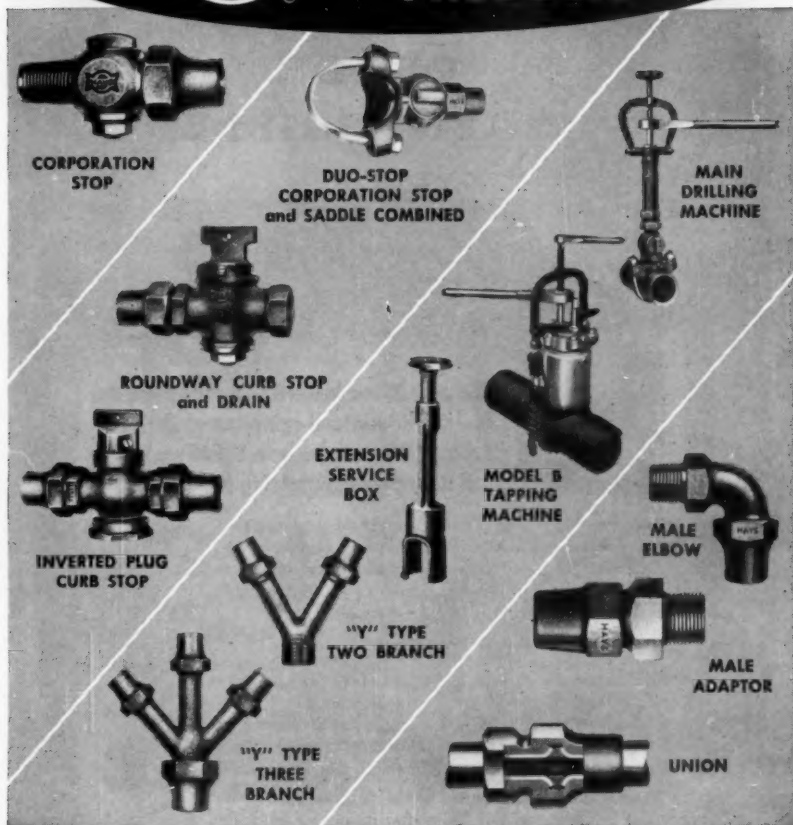
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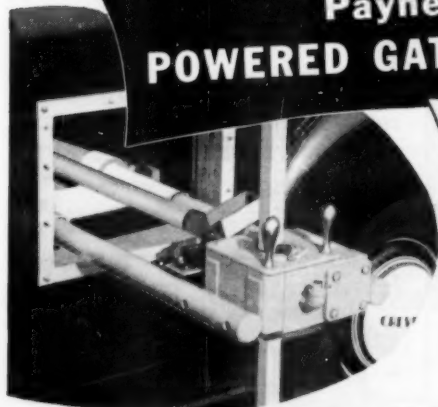


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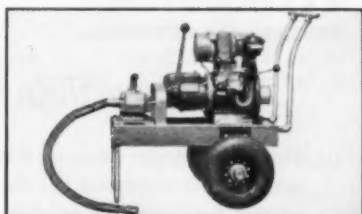
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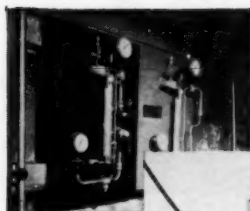
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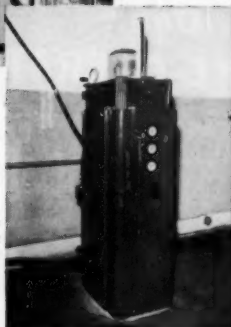
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W&T 1919 type  
mechanical diaphragm  
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Modern W&T type  
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June 26, 1955

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Very truly yours,

*R. D. Wright*  
R. D. Wright, Director  
Water Department

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DEPENDABLE SERVICE...**

*"...for more than thirty-five years..."*

Mr. R. D. Wright, Director, City of Lynchburg Water Department writes, "Your equipment has stood up under what we believe to be adverse conditions, and its performance has been very satisfactory." Lynchburg, Virginia has been using Wallace & Tiernan Chlorinators since 1919. *The original units are still in service*, along with more modern W&T equipment.

When you purchase a W&T Chlorinator, you purchase more than apparatus. You buy experience. Experience that brings you equipment design and materials of construction that have been selected and proven by years of use.

Lynchburg is not the exception. When your W&T representative visits you he can tell you about W&T chlorinators in your area, which are still giving dependable service after years of use.

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# Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 48 • JANUARY 1956 • NO. 1

## The American Water Works Association 1881-1956

**Frank C. Amsbary Jr.**

*An address presented on Jun. 16, 1955, at the Annual Conference, Chicago, Ill., by Frank C. Amsbary Jr., Pres. of American Water Works Assn.; Vice-Pres. & Gen. Mgr. of the Long Island Water Corp., Lynbrook, N.Y.*

**S**EVENTY-FIVE years ago, when the American Water Works Association was founded, there were fewer than 1,000 public water supply systems in this country, and only a few rudimentary water treatment systems. But the objective then was not so different from that of today. To state it simply, it was, and is, the banding together of professional water works men in an association where they could share experiences and work out common problems for the benefit of all.

### Organization Meeting

To institute that first meeting, the following letter was sent out to a group of prominent water works men:

### KEOKUK WATER WORKS

Jan. 18, 1881  
Keokuk, Iowa

DEAR SIR:

Having been requested to take the initiative in calling a convention of superintendents of western water works, you will confer a favor by advising me by return mail whether the project meets your approval—whether you will attend, and at what city you would prefer the convention to be held.

Respectfully Yours,  
W. C. STRIPE

*Superintendent of Water Works*

In response to the letter, on Mar. 29, 1881, 24 men met in Engineers Hall at Washington University, St. Louis. Thus began the American

Water Works Association, which has become the largest group of organized professional water works men in the world. The vision of this small group of men can be illustrated by pointing out that the Association is the fourth oldest scientific society in the Engineers' Joint Council, being preceded only by the American Society of Civil Engineers, 1852, the American Institute of Mining and Metallurgical Engineers, 1871, and the American Society of Mechanical Engineers, 1880.

Such men of vision should be recognized and never forgotten. Pursuant to the call issued by Stripe, secre-

Quigley of Atchison, Kan.; William H. Burnam of Batavia, Ill.; W. L. Cameron of Memphis, Tenn.; William Ratekin of Jacksonville, Ill.; and Col. J. T. Foster of Chicago, Ill., who became the first president.

### Membership Growth

By 1890 the membership of the association had reached 400. In 1900 it had been reduced to 350. In 1910, however, the membership reached 1,000 for the first time, and steadily grew, as shown in Table 1.

The year 1910, when the association reached its 1,000 mark, was also the year when John W. Alvord of Chicago was elected president. Alvord, along with H. E. Keeler, who was then superintendent of the Oak Park, Ill., water department, and Edward Bartow, who was head of the chemistry department at the University of Illinois, effected a series of acts which greatly improved the Association's standing. In 1912, they brought about the incorporation of the Association in the state of Illinois, and the address of official record for the Association is still the same as that of the firm which bears the name of John Alvord as the senior partner.

TABLE 1

#### Membership Growth

Membership	Year Reached
2,000	1924
3,000	1938
4,000	1941
5,000	1944
6,000	1946
7,000	1947
8,000	1950
9,000	1953
10,000	1954

tary and superintendent of the Keokuk Water Works, the following officers of water companies and other interested people met in convention on Mar. 29, 1881: W. C. Stripe of Keokuk, Iowa; Charles A. Smith, John W. Harrison, F. L. Kimball, Sylvester Watts, T. J. Rembert, and C. E. Gray of St. Louis, Mo.; H. G. Belche and James Milard of Peoria, Ill.; M. Donohue and Alex. Miller of Davenport, Iowa; J. H. Decker and H. D. Wood of Hannibal, Mo.; Ira A. Holly of Burlington, Iowa; M. X. Chuse of Bloomington, Ill.; J. G. Briggs of Terre Haute, Ind.; John Long of Louisville, Ky.; J. B.

### Sections Created

In 1914, with the leadership of these three men, two steps of major importance were taken. The first was the authorization for the creation of sections. Before 1914, the Association had but one convention a year and published only an annual volume of proceedings. While a number of the leading men in the water works industry had become associated with it, it could not command the attention of the

great majority of water works personnel for the rather simple reason that it was rarely possible for them to meet with other men of the industry. And so sections were created, the New York-New Jersey Section being the first one organized. The original Iowa Section was the second. Today there are 30 sections—28 in the US, one in Canada, and one in Cuba.

### Publications

The second step, taken in 1914, was the establishment of the *Journal*. It first appeared as a quarterly, then as a bimonthly publication. Since 1925 it has been published twelve times a year. In 1946 there was added to the periodical publication list the pamphlet, "Public Relations at Work," which is now circulated bimonthly as *Willing Water*. It is a vehicle of information concerning public relations activities for our industry. In 1950 there was established the interim publication "Defense News," which continued for five more issues in the succeeding year, bringing to the members information concerning the war-related activities of the industry.

The Association's first entry into the standardization field was recorded in a committee report condemning a type of pipe known as "Kalamein," which was presented at the fifth meeting of the Association in Boston, Mass., in 1885. The first affirmative standardization work was a set of standards for cast-iron pipe which was published in the proceedings for 1890. No official direction to standardization work was given by the Association until 1920 when, at the Montreal convention, George W. Fuller proposed that there be established a Council of Standardi-

zation. The plan was approved. Fuller was made chairman and the early members of the committee were Frank A. Barber, W. S. Cramer, W. W. DeBerard, Edward E. Wall, and Malcolm Pirnie. In 1925, the designation of the coordinating committee became the Committee on Water Works Practice, and Malcolm Pirnie succeeded Fuller as chairman. He continued in this capacity until 1947, when Louis R. Howson was appointed chairman. Howson still continues in that capacity.

The first flowering of the Council on Standardization was manifested in the publication of the *Manual of Water Works Practice* in 1925. There were successive printings of this until the first edition of the *Manual of Water Quality and Treatment* appeared in 1940. In cooperation with the Municipal Finance Officers' Association, AWWA developed a *Manual of Water Works Accounting* in 1938. This volume is still available.

*Standard Methods for the Examination of Water and Sewage* was first developed by an American Public Health Association committee under the leadership of George W. Fuller. This continued as an exclusive APHA enterprise until 1925, when Fuller negotiated an agreement by which the AWWA became cosponsor with APHA. In 1955 the tenth edition of this manual was issued, and a third sponsor, the Federation of Sewage and Industrial Wastes Associations, has joined APHA and AWWA.

In 1948 the Association published the monumental text *The Quest for Pure Water*, which had been developed by M. N. Baker, former editor of *Engineering News Record*. The book was

a compilation of the lifetime labor of Baker, and to the present time it has no parallel in the area of public water supply.

The Committee of Water Works Administration was established in 1948 with Wendell LaDue as chairman. LaDue still continues in this capacity. The records of the activities of the Water Works Practice Committee and the Committee of Water Works Administration are published annually in the March issue of the *Journal*. Along with these records is published the auditor's report of the Association's finances. This is a routine of many years' standing.

### Technical Divisions

In recent years the Association's technical divisions have reached a status where the present four divisions—water resources, water purification, distribution, and water works management—have become the framework about which much of the standardization and procedural work is initiated. The divisions also afford the logical setting for the sessions in the annual convention of the Association. In later years, the great contribution of these divisions to the progress of the Association may be considered as the forward step taken in the 1950's.

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### Amendment of AWWA By-Laws

In view of the increase in AWWA membership, the Committee on Honorary Membership suggested that the ratio of Honorary Members to Active Members be changed from the present 1:125 to 1:150, and that the permissible number of Honorary Members elected in any one year be increased to four, with provision for further increase as the Active Member total grows. Accordingly, the Board of Directors, on Nov. 23, 1955, approved the following amendment to Article II, Sec. 1.3 (replaces existing Sec. 1.3):

1.3. No election to Honorary Membership shall be made which would cause the total number of Honorary Members to exceed a ratio of one Honorary Member to every 150 Active Members. Not more than four Honorary Members shall be elected in any one year unless the Active Membership of the Association shall pass a total of 10,000 Active Members, in which event the permissible number of Honorary Members elected in any one year shall be increased by one Honorary Member for every increase of 1,000 Active Members.



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## Identification, Significance, and Control of Suspended Solids

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**Selden K. Adkins and B. J. Wachter**

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*A paper presented on Jun. 13, 1955, at the Annual Conference, Chicago, Ill., by Selden K. Adkins, Mgr., Consulting Service, and B. J. Wachter, Tech. Services, Boiler Feedwater Dept., both of National Aluminate Corp., Chicago, Ill.*

**A** SOURCE of water that is abundant, clear, and chemically suitable for all uses is very unusual. Streams, lakes, or wells always contain some dissolved substances from the soil or earth strata that they contact. Suspended solids in the form of silt, debris, waste, and precipitates are more often present than not. Colloidal material may add to the long list of undesirable items present.

There are methods for chemically treating to correct such conditions. Clarification of water removes most of the suspended and colloidal material without difficulty. Filtration, after clarification, will reduce to very low values the remaining turbidity. Some of the objectionable dissolved solids can be removed or reduced by softening. When final use necessitates such measures, demineralization or evaporation will remove nearly all remaining dissolved solids.

Only suspended solids in low- or moderate-pressure boilers will be discussed here, and it will be assumed that suspended material has been removed from the water source by pretreatment. Even when one or more of the above pretreatment methods are used, suspended solids in the boiler water will result from chemical changes in the remaining dissolved solids in the feedwater or from corrosion products

removed from the feed line, economizer, and condensate system. Physical, thermal, and chemical environments in the boiler contribute to these chemical changes. With proper control and a planned chemical treatment program, suspended solids are harmless. Improperly controlled, they result in sludge, scale, and excessive deposits that usually force shutdown of the unit for cleaning or failure of tubes and flues. Suspended solids sometimes cause foaming, carryover, and poor steam quality. Minimizing the possible bad effects of suspended solids in boiler water requires careful consideration of the following factors:

1. Identification of those dissolved solids, including corrosion products, that are potential suspended solids
2. An understanding of the significance of the precipitation conditions of the various suspended solids encountered and the relative tendencies of each to adhere to heat transfer surfaces
3. Control of suspended solids by proper precipitation methods, conditioning of the precipitates formed, and ultimate removal of the sludge by blowdown.

### Identification

Analysis of the feedwater and makeup is essential. From this information, reasonable predictions can be

made as to the type and amount of suspended solids that will form in the boiler. Soluble calcium and magnesium compounds in the feedwater usually form the bulk of the potential suspended solids found in the boiler water.

Calcium will precipitate as carbonate, sulfate, silicate, orthophosphate, or hydrated orthophosphate. Magnesium is most likely to precipitate as carbonate, silicate, hydrate, or hydrated orthophosphate.

Suspended solids in boiler water resulting from corrosion products dissolved or suspended in the feedwater are difficult to predict by analysis. Iron and copper from condensate or feedwater systems are the most common of these corrosion products. Metallic corrosion products, when they become suspended solids, are generally found as oxides. If they are suspended in the feedwater in this form, their identification is a sampling and analysis problem considerably more complex than the determination of calcium and magnesium. Whenever these items are suspected to be a potential suspended-solids problem, however, the effort to identify them is worthwhile.

Silica, under some chemical and thermal conditions, may become a precipitation problem. In the feedwater it is generally dissolved, but it can be present in suspended or colloidal form, especially if the system involved does not include pretreatment that will remove finely divided material. When normally high alkalinities are maintained in the boiler water, silica stays in solution in relatively high concentrations. Even when silica is introduced into the boiler in suspended or colloidal form, the high alkalinity will normally cause it to dissolve. Identification of suspended solids in the boiler will be affected by the amount of silica present in the feedwater, so determination of

total suspended, colloidal, and soluble silica should be made.

The most conclusive identification technique, of course, is the application of either or both gravimetric and X-ray analysis methods to actual boiler deposits. These methods are very reliable and their results should always be carefully interpreted to achieve maximum benefit from chemical control. Shutdown of a boiler for the sole purpose of obtaining such samples, however, is usually entirely impractical and uneconomical.

Identification of all possible potential and actual suspended solids is necessary for achieving a successful program of preventing boiler deposits. Complete analyses, with carefully selected samples of makeup, condensate, feedwater, and boiler water, will identify potential or existing problems.

### **Significance**

With very few exceptions, all boilers contain either actual or potential suspended solids. Potentially all suspended solids are scale, sludge, or undesirable deposits. The amount and type present, in relation to the basic method of chemical treatment used, determine the success or failure of the treatment program. A boiler system with 10 per cent zeolite-softened makeup, for example, would use "phosphate excess" treatment for the boiler and quite low suspended solids would result in the boiler. On such a system, suspended solids which were consistently higher than 15 or 20 ppm would signify potential trouble with boiler deposits. Proper operation of the zeolite softener, adequate control of corrosion in the condensate system, and exclusion of hardness inleakage to the condensate system would provide a very low-potential suspended-solids

feedwater. Investigation by analysis should promptly determine if one or more of the possible sources of potential solids are contributing hardness or corrosion products to the system. A plant of this type, with reasonable care in operation and control, should operate reliably with negligible boiler deposits, or none at all, for long periods of time.

TABLE 1  
*Boiler Deposits\**

Acmite— $\text{Na}_2\text{O} \cdot \text{Fe}_2\text{O}_3 \cdot 4\text{SiO}_2$
Analcite— $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2 \cdot 2\text{H}_2\text{O}$
Anhydrite— $\text{CaSO}_4$
Aragonite— $\text{CaCO}_3$ (gamma form)†
Basic magnesium phosphate— $\text{Mg}_2(\text{PO}_4)_2 \cdot \text{Mg}(\text{OH})_2$
Brucite— $\text{Mg}(\text{OH})_2$
Calcium hydroxide— $\text{Ca}(\text{OH})_2$
Calcite— $\text{CaCO}_3$ (beta form)†
Copper— $\text{Cu}$
Cuprite— $\text{Cu}_2\text{O}$
Ferrous oxide— $\text{FeO}$
Goethite— $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ (alpha form)†
Gypsum— $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ †
Hematite— $\text{Fe}_2\text{O}_3$
Hydroxyapatite— $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$ †
Magnetite— $\text{Fe}_3\text{O}_4$
Serpentine— $3\text{MgO} \cdot \text{SiO}_2 \cdot 2\text{H}_2\text{O}$
Sodium ferrous phosphate— $\text{NaFePO}_4$
Tenorite— $\text{CuO}$
Thenardite— $\text{Na}_2\text{SO}_4$
Xonotlite— $5\text{CaO} \cdot 5\text{SiO}_2 \cdot \text{H}_2\text{O}$

\* All the deposits are formed only at temperatures above  $100^\circ\text{C}$  with evaporation, except for those marked †, which will also form at temperatures below  $100^\circ\text{C}$ , with or without evaporation.

In contrast to the above system is a boiler system with 70 per cent raw-water makeup and internal coagulation-type treatment, with the makeup containing 100 ppm of total hardness. Blowdown samples from such a system should have voluminous, flocculent, suspended solids. If the boiler water is cloudy, with fine turbidity in small amounts, it is obvious that large quantities of suspended solids are not being properly formed and removed from the boiler. In this case, it is evident that adjustment of chemical treatment is

necessary to coagulate and condition properly the high suspended solids that must result from the approximately 70 ppm of hardness entering the boiler.

Failure of tubes, either by bagging or rupture, necessitates complete investigation. Thorough evaluation is necessary to make certain that all involved factors are considered. The amount, location, and composition of deposits are factors that must be known. In addition, metallographic examination of the faulty tube may add to the evidence. When facts of this nature are available, it is possible to determine the significance of suspended solids in the problem and then take steps to correct the condition that is permitting the deposition. Several other factors can contribute to tube failures and, of course, must not be ignored, but the importance of improperly conditioned suspended solids and the detection of their part in the failure is the main interest of this discussion.

In connection with the significance of deposit composition, ASTM (1) has made a summary of various deposits formed (*see* Table 1). Some of these deposits are quite common when suspended solids are improperly handled in the boiler.

The effect of suspended solids on steam bubble formation and release is a complex physical phenomenon. It is known, however, that when conditions of precipitation and control are incorrect, suspended solids cause serious foaming. The resulting carryover of boiler water containing suspended and dissolved solids is a very expensive and troublesome problem. The significance of suspended solids in foaming problems demands careful consideration in selecting the method of chemical treatment. The effective antifoams used in combination with organic-sludge con-

ditioners offer control of foaming and carryover.

It is evident, therefore, that the type, quantity, and conditioning of suspended solids in boiler water are significant factors in maintaining extended, trouble-free operation of the unit.

### Control

In low- or moderate-pressure boilers (maximum 350 psi), feedwater with relatively large amounts of potential suspended solids may be introduced directly into the boiler without pretreatment, and the resulting suspended solids will be formed under controlled conditions. This method is called internal or coagulation-type treatment. The primary goal is precipitation of calcium carbonate and magnesium hydrate or silicate under chemical conditions that cause a soft, fluid, flocculent sludge which settles rapidly and has little tendency to adhere to the metal surfaces of heat-exchange areas. This permits effective removal of the precipitated solids by regular or continuous blowdown.

The precipitation is achieved with softening alkalies—soda ash ( $\text{Na}_2\text{CO}_3$ ), or caustic soda ( $\text{NaOH}$ ), or a combination of the two—and small amounts of an organic compound and orthophosphate. Each feedwater must be analyzed and the treatment must be selected on the basis of hardness, silica content, and alkalinity. Phosphate and organic-compound quantities must be correctly controlled. It is essential that the amount of orthophosphate present be sufficient to inhibit formation of calcium sulfate, but not large enough to result in an unreacted "phosphate excess." Organic compounds, properly selected and applied, act as an aid to coagulation, and condition the floc particles so they will be

fluid and non-adherent. In most cases this method is applied when feedwater hardness is above 35 ppm.

From a practical operating viewpoint, experience in application and actual visual inspection of the coagulated suspended solids is one of the most effective controls. When combined with simple alkalinity titration, dissolved-solids determination, and the familiar soap hardness test, control is assured and internal surfaces of the boiler can be kept free of scale.

While hundreds of boilers are being treated with internal methods, the tendency on newer units is toward reduction or removal of potential suspended solids before the feedwater enters the boiler. There are several methods of softening, and each should be scrutinized in terms of the makeup water available. The newer ion-exchange processes such as dealkalization and demineralization are very effective and may be necessary for some low- or moderate-pressure units. In most cases, softening alone will prove adequate for the boiler pressures considered here (up to 500 psi).

Even the most modern and carefully operated softening plant does not reduce hardness to an absolute zero value. When either hot or cold precipitation-type softening is employed, appreciable amounts of calcium and magnesium remain. In all cases, there is a definite need for the "phosphate excess" type of treatment, which has, as its primary goal, the precipitation of calcium as an orthophosphate, and magnesium as the hydrate or silicate.

Regardless of the type of phosphate finally selected, organic-sludge conditioning is a very desirable and necessary chemical treatment. Several positive advantages can be obtained. Ideally, the calcium and magnesium

precipitates should be rapidly formed in the body of the boiler water, their size immediately limited to assure easy dispersion, and their removal achieved by continuous blowdown. Limiting the particle size is the primary function of the organic. When there is proper alkalinity, the particle size will be small. Jacklin and Holmes (2) observed that particle size decreased as alkalinity increased. It is efficient, therefore, to maintain the highest hydrate alkalinity that is compatible with the total solids permissible. The fine particle that results will be stained by organic compound present and its growth will be arrested. Removal through the continuous blowdown is then assured.

In the boiler water, potential suspended solids in the form of corrosion products, usually iron or copper, are more prevalent in low-make-up plants having large condensate-recovery systems. Oxygen and carbon dioxide dissolved in the water are generally the corrosive agents. Mechanical deaeration will reduce the dissolved gases. Application of catalyzed sodium sulfite into the feed line will remove the remaining oxygen. Great advances have been made and reported (3-6), in the field of prevention of corrosion with both volatile and filming amines. When these materials can be economically applied and properly controlled, they should be used. By reducing or eliminating the corrosion products from the feedwater, these amines greatly simplify control of suspended solids in the boiler. In systems with low makeup and pre-softening, corrosion products become an important percentage of the potential suspended solids in boiler water. The organic compound, which was previously mentioned, is even more necessary under these conditions. Processed organic-compound condi-

tioners can minimize deposition of iron and copper oxides. For the greatest success, both corrosion prevention in the preboiler system and organic-compound conditioners should be used.

The adverse effect of oil on suspended solids is important. Because it coats both suspended solids and the internal surfaces of the boiler, oil causes a sticky condition that greatly increases deposit formation. By interference with precipitation, coagulation, or dispersion, it can upset control and further complicate the problem. Another undesirable characteristic of oil is that it is notorious for causing foam.

Control of oil is best applied outside of the boiler. Reduction of lubricating oil feed into the steam ahead of equipment to the lowest practical amount, and elimination of unnecessary oil contamination of condensate and feed water, must be accomplished. Here, again, the use of organic, particularly the starch type, can be very helpful. An antifoam, also, is essential.

Regardless of the pretreatment method or the boiler chemicals used, blowdown control of both suspended- and dissolved-solids concentrations and control of chemicals to the boiler is essential. Either may be intermittent or continuous. Intermittent blowdown may be from the steam-water drum, mud drum, mud header, or lower water wall header. The specific location is determined by the boiler design. Continuous blowdown is usually taken from the steam-water drum, slightly below the water level. It is very desirable to provide connections from all the points mentioned. Even when continuous blowdown is the normal control method, periodic blowdowns from the lowest points in the unit will minimize deposits.

Continuous blowdown and chemical feed have definite advantages. Chemi-

cal treatment and concentrations of dissolved and suspended solids can be maintained at an even level, and suspended solids deposition reduced. When combined with a regular analytical program, very good control is achieved.

Two simple and reliable methods of determining concentrations of dissolved solids are electrical conductivity and the chloride determination. Unfortunately, the suspended solids are not as easily determined. Gravimetric determinations of both dissolved and total solids must be made in order to determine the amount of suspended solids present by difference. Nor-

(7) shown in Table 2. These recommendations are based on extensive study and experience and they should not be exceeded without very careful consideration of all the factors concerned.

### Conclusions

It has been the experience of the authors that failure to recognize the importance of identification, significance, and control of suspended solids in boiler water has resulted in expensive and unscheduled shutdowns of boilers and plants. Careful and complete study aimed at identification of potential suspended solids in the makeup and feedwater, recognition of the significance of those which are undesirable, and preparation of an effective control program are economical and extremely beneficial measures. The time, effort, and money spent on planning, before the unit is started, have paid dividends in minimum outage, low maintenance costs, and satisfactory operating expense.

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TABLE 2  
Boiler Water Concentration  
Specifications

Boiler Pressure psig	Maximum Total Solids in Boiler Water—ppm
0-300	3,500
301-450	3,000
451-600	2,500
601-750	2,000
751-900	1,500
901-1,000	1,250
1,001 and higher	1,000

mally, it is not practical or necessary to make frequent determinations of either dissolved or suspended solids gravimetrically. Shift or daily testing of dissolved solids is usually sufficient. In unusual cases, or during the initial operation of a boiler, turbidity measurements on carefully selected samples by Nesslerization or photometric methods can be more rapidly obtained and are very helpful.

The maximum allowable total solids permissible are a function of boiler design and pressure. Each manufacturer states a recommended maximum for his unit, generally in line with those set by the American Boiler and Affiliated Industries Standards Committee



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## Corrosion Problems in Small Heating Boilers

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**H. F. Hinst**

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*A paper presented on Jun. 13, 1955, at the Annual Conference, Chicago, Ill., by H. F. Hinst, Chief Metallurgist, Tubular Products Div., The Babcock and Wilcox Co., Alliance, Ohio.*

**L**OW-PRESSURE heating boilers are, by ASME definition, those which operate at a maximum steam pressure of 15 psi or a maximum water pressure of 160 psi at a maximum temperature of 250°F.

These boilers are used primarily for heating and are found in homes, office buildings, churches, apartment houses, greenhouses, bakeries, and schools. They do not require constant attendance and they are usually automatic. Because of the size of such boilers and the small quantity of materials needed for corrosion prevention, the manufacturers of water treatment chemicals cannot afford to provide the supervisory service which, in high pressure installations, tailors the treatment to the particular requirements of the boiler by instructing operators and periodically checking the application of the treatment. As a result, the owner of a heating boiler is left to his own devices and often, because of his limited experience, uses products and methods which may intensify his difficulties rather than lessen them.

The problems which arise in heating boilers are not impossible to solve, however. The chief difficulty is usually that of corrosion alone, the complex problems of scale formation not being involved. The same principles of corrosion prevention, however, are applicable to both high- and low-pressure boilers.

### Causes of Failure

Understandably enough, the owner of a heating boiler, who rightly expected 20 years of service, usually blames the tubes when leaks occur after 1 or 2 years of operation. The Babcock and Wilcox Co. has had over 50 years of experience in the manufacture of boiler tubes and during that time has examined many tubes to determine the cause of failure. Only occasionally has defective quality of the tubes been found to be the cause of failure. In the vast majority of cases, it was environmental conditions which were at fault.

Corrosion is the main problem in heating boilers because practically all the steam or water is returned to the boiler. In a properly operating heating system, where there are few losses, there is little, if any, makeup water required. Hardness salts, therefore, do not concentrate and little scale is formed.

The two main types of failure in heating systems are pitting from the water side and wasting from the fire side. Heating boilers are generally of fire tube construction. In this type of boiler the products of fuel combustion pass through horizontal tubes immersed in the water so that fire is on the inside and water is on the outside of the tubes. The condensate or fresh

water usually enters at the bottom of the boiler, rises as it is heated, and leaves from the top of the boiler as steam or hot water.

### Pitting

Pitting from the water-side is the most common type of failure. The frequency of the pits is generally considered to be a function of the pH of the water and the dissolved oxygen con-



Fig. 1. Oxygen Pitting on Water-Side of Fire Tube

*Pitting on the water side of tubes is usually along the top surfaces.*

centration. An example of a pitted tube is shown in Fig. 1. In most instances, the pitting is concentrated largely along the top surface of the tubes.

### Effects of Oxygen

There are numerous ways by which oxygen gets into a boiler. From contact with the atmosphere, all surface water supplies dissolve air in varying quantities, depending on the length of time of contact, the turbulence of the water, and the water temperature. The solubility of oxygen is such that at low water temperatures more will

be retained than at higher temperatures. This is demonstrated by the way in which a glass filled with cold water forms air bubbles on its sides as the water warms to room temperature. Figure 2 shows the relationship between oxygen solubility and temperature. Since dissolved oxygen and low alkalinities in the water favor corrosion, as shown in Fig. 3, it follows that corrosion can be lessened by removing the oxygen and maintaining high alkalinities.

Oxygen may be removed from the feedwater before it enters the boiler by preheating the water until it is at, or near, the boiling point. This method is used in most modern higher-pressure installations, but is not common in residential-type boilers because their sale is quite competitive and the additional expense of feedwater-heating devices is not a good selling point. Although such a savings to the customer may not be wise, when it is considered that trouble develops in only a very small percentage of low-pressure installations, it is not surprising that a heater is not a common piece of auxiliary equipment.

Since dissolved oxygen is not desired in the feedwater, it follows that any practice which requires additional makeup should be discouraged. Some owners have a habit of draining small amounts of water from their boilers periodically. Blowdown is necessary in larger boilers where appreciable quantities of steam are lost, but it is neither necessary nor desirable in heating boilers.

Older hot-water heating systems seldom gave trouble, but with the advent of modern practice, smaller boilers, and forced circulation, there is more reason for occasional corrosion to result. Pumps can force considerable quantities of air into such systems

at leaking glands. Fresh makeup water can be constantly added by automatic float valves located in surge tanks at the high point in the system. The water level rises and lowers by the expansion and contraction caused by temperature change. If the float valve is set too high, water is lost at each expansion and made up automatically at each contraction, thus admitting fresh oxygen-bearing water which causes pitting. Waterlogged floats and small leaks in the system result in re-

uum, and air may still infiltrate through faulty valves, pipe joints, and pump packings. Air may be satisfactorily released at vents during operation, but it will fill the vacuum in the piping when the system shuts down, as on warm days. It is apparent that proper maintenance of a heating system is absolutely essential.

Once it has entered a system, oxygen can be removed by periodic additions of sodium sulfite, which reacts chemically with it. An addition of

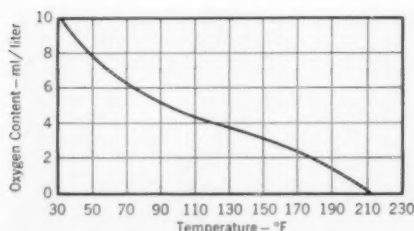


Fig. 2. Oxygen Solubility at Various Temperatures

Because oxygen content is less at higher temperatures, preheating the feedwater is one method of avoiding the pitting which results from high oxygen content.

placement of water with the same results.

A heating boiler should not be drained in the spring or summer and filled with fresh water unless precautions are taken to prevent corrosion. If it is necessary to drain a boiler, it should be laid up dry unless the boiler furnace is to be used for burning refuse. When that is the case, the boiler should be filled with water, brought to a boil with safety cocks open to release gases, supplied with chemicals, and then closed up tight.

Probably more important sources of oxygen are at leaks in the distribution and return system. The return system may be under a constant vac-

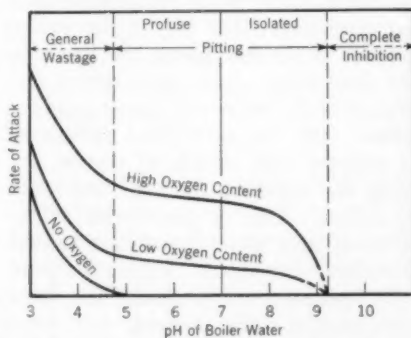


Fig. 3. Steel Corrosion Related to Condition of Boiler Water

*High oxygen content and low alkalinities both favor corrosion.*

this chemical is also recommended prior to the summer layup.

To help prevent corrosion, boiler water should be kept above a pH of 11.0 by regulated addition of alkaline chemicals such as sodium hydroxide, sodium carbonate, or trisodium phosphate. Two ounces of sodium hydroxide per 100 gal of boiler water will usually result in the proper pH. The need for further additions can be determined by a simple color test.

New or retubed boilers should be boiled out with cleaning compounds to remove the oils and greases which are picked up during manufacture or are

put on the tubes as protective coatings. A boilout with one of the newer detergents or a mixture of  $2\frac{1}{2}$  lb of caustic soda and  $2\frac{1}{2}$  lb of soda ash can effectively remove these foreign materials.

### Effect of Moisture

Attack on the fire-side of the tube was responsible for 15 per cent of the failures which were noted. An example of such corrosion is shown in Fig. 4. It is caused by condensation of moisture during shutdown periods or condensation of sulfur compounds during operation. The higher the sulfur content of the flue gases, the lower is the dew point. Low-temperature operation of the boiler may cause condensation, with the subsequent formation of sulfuric acid, which, of course, attacks and dissolves the steel and leads to failure. Oils or coals with sulfur contents over about 2 per cent should therefore be avoided. Figure 5 shows safe operating temperatures for fuels with various sulfur content.

Proper firing and neatness are also important for effective performance. Soot should not be allowed to accumulate in the tubes because it is hygroscopic and the combination of air and moisture results in fire-side attack. Daily, weekly, or monthly brushing may be necessary to keep the surfaces clean.

Greenhouses are especially susceptible to this form of attack, because of the extreme humidity present in their operation and their common practice of sterilizing earth in the summer at temperatures of  $140^{\circ}$ – $160^{\circ}$ F. Such boilers should not be drained and refilled with cold water and allowed to stand, since the humid atmosphere will encourage condensation on the cool tube surfaces.

When a boiler is shut down for the summer, the fire-side surfaces should be cleaned and, preferably, oiled, and a tray of moisture-absorbing chemicals, such as unslaked lime or silica gel, should be placed in the fire pit. These chemicals should be replaced when their becoming mushy indicates that their capacity to absorb moisture has been lost. The boiler should be closed tight, and, in extremely damp locations, the stack should even be disconnected. Standing water should not be tolerated



Fig. 4. Fire-Side Attack

*This type of corrosion is caused by moisture condensation and is responsible for about 15 per cent of failures.*

in the boiler room. Dampness, of course, exists in most basements, especially during the summer, as proved by the ready market for moisture-absorbing chemicals and dehumidifiers.

### Electrolysis

Many heating boilers contain a copper water-heating coil suspended in the water space. According to the galvanic series, the steel in the tubes should be corroded if the copper contacts it, or if the arrangement is such that induced electrical currents can flow in a circuit. To the author's knowledge, however, there have been

no indications that any failures have been due to this action, even when these coils actually contact the tubes.

Electrolysis has been held responsible for many failures. The term is used rather vaguely, however, and might include galvanic action or possible corrosion from stray electrical currents. These stray currents cause corrosion only if they enter and leave the equipment, the corrosion taking place when the current leaves the piping. This type of damage occurs only with direct current, however. Alternating current has no such effect. Street cars are the major cause of electrolysis attack, because the ground current returns to the powerhouse by the shortest electrical route. Occasionally, grounded telephone lines have caused the same difficulties. Attack from stray currents, however, is very uncommon and should not be considered until all other possibilities have been exhausted.

### Waterline Corrosion

In vertical fire-tube boilers corrosion takes another form. This type of boiler consists of a vertical, cylindrical shell built around a number of small diameter tubes which are also vertical. The products of combustion travel up through the tubes, imparting heat to the surrounding water, which only partly fills the shell. These boilers are commonly used in dry-cleaning establishments and, in such use, because of the steam losses in pressing clothes, makeup water is usually a high percentage of feed. The relatively large quantities of dissolved oxygen in the raw feedwater cause corrosion of the tubes at the waterline, as shown in Fig. 6.

Corrosion of this type is attributed to a difference in oxygen concentration

existing in the meniscus versus the main body of water. Because of large blowdown requirements, small boiler capacity, and the operator's lack of experience, the treatment problem is difficult. The problem, therefore, resolves itself into one of dispelling the dissolved oxygen and preventing scale formation. To dispel the dissolved oxygen, the return-condensate tanks, which are standard auxiliary equipment on most vertical fire-tube boilers, can be fitted with a steamline and, by installation of vents, act as deaerating feedwater heaters. This will result in the longer life of the tubes. Scale formation must, of course, be avoided by proper treatment.

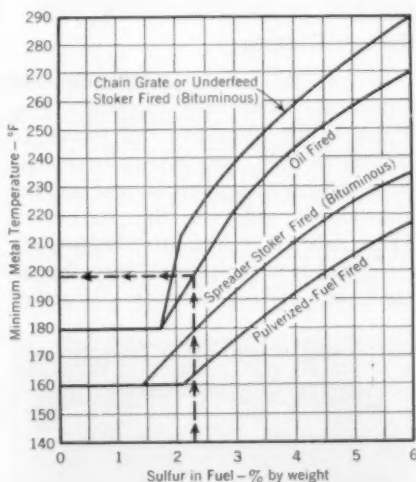
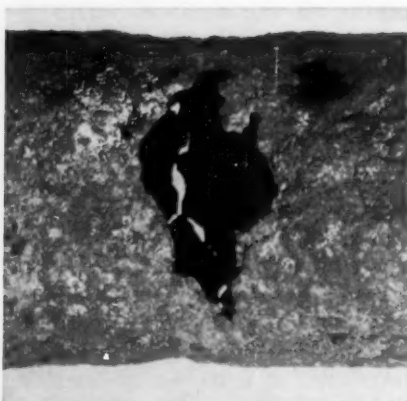


Fig. 5. Safe Operating Temperatures for Fuels of Various Sulfur Contents

The safe minimum metal temperature, as shown here for coal, fuel oil (grades No. 1-6), and natural gas, is the temperature as limited only by sulfur content of the fuels. For anthracite or natural gas without sulfur content, the minimum metal temperature is 160°F.

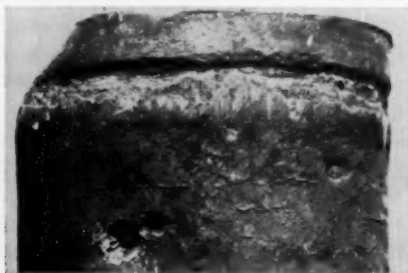


**Fig. 6. Corrosion at Waterline**

*This type of corrosion occurs in boilers with vertical fire tubes, usually used in establishments where there is high steam loss.*

### Carbon Dioxide

In larger installations return-condensate lines may corrode. This is due to the formation and release of carbon dioxide, which usually results from calcium, magnesium, and sodium bicarbonate salts in the feedwater. These salts, in a feedwater heater, are converted into carbonates, with the release of carbon dioxide. Further



**Fig. 7. Grooving in Area Adjacent to Tube Sheet**

*The grooving is a form of low-frequency stress corrosion and is thought to result from a flaking away of protective films.*

breakdown occurs in the boiler, forming sodium hydroxide and more carbon dioxide. The conversion is estimated to be 80 percent. The carbon dioxide exits with the steam, joining with the condensate to form carbonic acid. This results in the grooving of return piping and failure of heaters. It is obvious that chemical treatment with sodium carbonate aggravates this form of attack.

Where carbonic acid corrosion is severe, the problem has been eliminated by converting the bicarbonate salts to carbonic acid in hydrogen zeolite cation-exchange units. Release of the carbon dioxide can then be effected by heating the water in a feedwater heater.

### Amines

Various amines have recently come into common usage as treatments. When certain amines are added to the boiler water, they will, because they are volatile, pass off with the steam, condense with the water, and keep the pH of the condensate in the non-corrosive range. These amines have been found to be effective if the pH of the condensate can be maintained above 7.0. Loss of steam in process may make this treatment expensive. Also, these amines are not recommended for use at pressures above 300 psi because of the possibility of breakdown. The many amines available, therefore, must be tailored to the job according to operating pressure and temperature.

Filming amines are materials which protect the condensate lines by forming a film over the metal and producing a nonwetttable surface. Because they are not volatile, they are added directly to the steam. Another of their valuable characteristics is that it is possible to add them only to that portion of



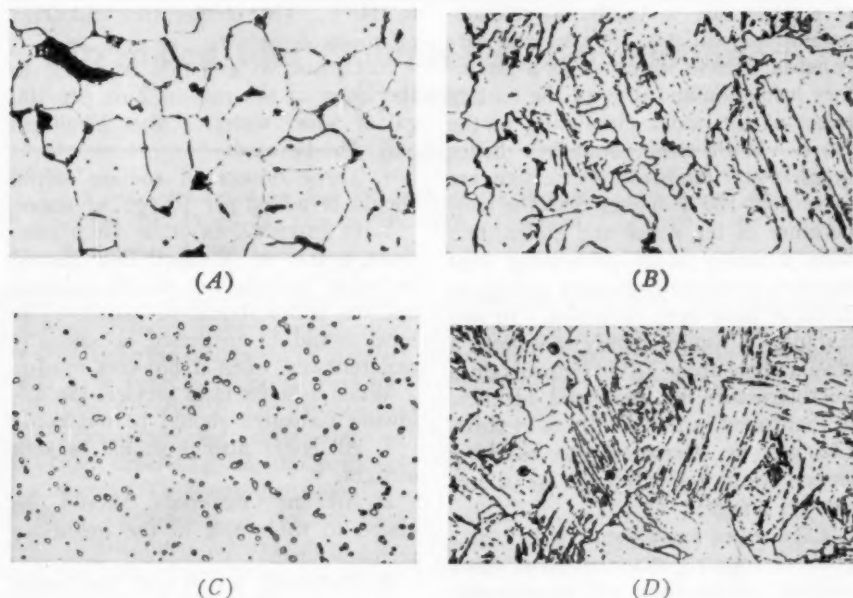


Fig. 8. Microstructures in Steel

The conditions of the samples were as follows: A—normal microstructure of boiler tubes; B—microstructures found in a burst tube; C—spheroidized structure in a failed tube which had been held at temperatures of 800°–1,300°F for a period of time; D—microstructures produced by quenching steel from 2,100°F.

the steam going to parts of the plant where there is no steam loss. Because they do not return to the boiler, and do not volatilize during boiling, they must be added continuously. A reputable water-treating company should be consulted before using filming amines.

#### Grooving at Tube Ends

Another type of corrosion which occasionally occurs results in grooving around the circumference of the tube in the area immediately adjacent to the tube sheet. Figure 7 shows an example of such grooving, which is caused by the stresses set up during the rolling-in operation, expansion and contraction from heating and cooling, and dissolved oxygen and low alkali-

linities. It is thought to result from the flaking away of protective films and is a form of low-frequency stress corrosion. Again, the cure for this is freedom from dissolved oxygen and the maintenance of sufficient alkalinities.

#### Overheating

Although it is not a problem in heating boilers and is not corrosion, overheating is another common reason for failure of tubes in higher-pressure installations of the water-tube type. Blistering and rupture of boiler tubes is caused by overheating the tube metal to the point where the internal pressure is sufficient to result in loss of metal strengths.

In most cases, the overheating of the tube metal is caused by the formation

of a scale due to hardness—calcium, magnesium, sulfates, silicates, and carbonates. These scales act as a refractory insulation and prevent the cooling effect of the water circulating in the tubes. With clean, scale-free boiler tubes, metal temperatures seldom are more than 150°F higher than the temperature of the water and steam, but, with a heavy scale preventing heat transfer, metal temperatures as high as 2,100°F have been indicated. In one instance, it was necessary to quench a steel sample from 2,100°F to obtain a microstructure in the metal identical to that found in the vicinity of rupture. Changes in microstructure resulting from various temperatures are shown in Fig. 8 and 9.

Even when scale seems absent at a point of rupture, examination of other sections of the tube will usually disclose its presence. This is because the swelling of the tube generally causes scale to flake and wash away before or during rupture. The obvious means to prevent overheating is to prevent scale formation, assure proper circulation, and prevent low water.

### Summary

For a boiler that is shut down, the following steps should be taken:

1. After installing new tubes, the boiler should be boiled out with an alkaline cleaner to remove oil or other coatings from the tube surfaces. These protective coatings are commonly applied to new tubes to prevent rusting during storage and transit, and they will cause corrosion if left on the tubes during boiler operation.

2. As soon as it is filled after draining, a steam boiler should be brought to a good steam output to deaerate the water. For the same reason the water in a hot water boiler should be heated

to 180°F. This temperature will drive off most of the air.

3. Caustic soda should be added to the water at the rate of 2 oz per 100 gal of boiler water. Other alkalizers may also be used.

4. Three ounces of sodium sulfite should be added per 100 gal of water.

5. In greenhouses or in damp locations, a tray of unslaked lime should be put in the ashpit to absorb moisture and the boiler should be closed. The lime should be inspected occasionally and renewed when it becomes mushy.

When a boiler is in service, the following measures should be observed:

1. All boiler fittings should be kept airtight.

2. Alkaline materials should be added to the water in the quantities recommended.

3. Preferably a fuel with low sulfur content should be used to avoid the corrosive action of sulfur gases.

4. The insides of fire tubes should be brushed, flushed, and dried out as often as possible to remove soot and other products of combustion, and to prevent the accumulation of moisture and condensed sulfur gases.

5. To remove dissolved oxygen, sodium sulfite should be used regularly in the boiler water.

6. A suitable feedwater heater or deaerator is recommended for reducing the oxygen content of the boiler feedwater.

7. Water leakage and periodic drainage of water out of the system should be avoided. These add to the requirements of makeup water, result in loss and dilution of the treatment, and introduce air into the system.

Following these simple rules will result in longer life to the boiler, freedom from boiler tube trouble, and will present an opportunity for the tubes to serve at their full capacity.

## Mixed-Bed and Multiple-Bed Demineralizing Systems

H. E. Bacon

*A paper presented on Jun. 13, 1955, at the Annual Conference, Chicago, Ill., by H. E. Bacon, Prin. Asst., Sheppard T. Powell, Cons. Engrs., Baltimore, Md.*

SINCE 1937, over 2,000 water treatment systems have been installed for producing the equivalent of distilled water by a process which is mechanically like filtration. The process is called demineralizing, deionizing, or desalting, depending on the point of view taken. To learn the magnitude of these operations, a canvass was made of six manufacturers who produce the bulk of industrial and utility water treatment equipment.

The information reported by these manufacturers is given in Table 1 and covers plants with capacities from 10 gpm to more than 2,000 gpm, but does not include several thousand units furnishing distilled water on a laboratory scale.

The table shows that, among systems using strongly basic anion-exchange resins, mixed-bed installations outnumber the multiple-bed plants. The purpose of this discussion is to bring out the more important characteristics of these two contrasting types of systems and to point out some operating difficulties that may be avoided.

### Background

The oldest and most extensively used method of demineralizing water is the multiple-bed system, using weakly basic anion exchangers. The

earliest demineralizers used sulfonated coal to convert salts to acids. The acids were then absorbed by synthetic resins of the ethylene-diamine type.

TABLE 1  
*Number of Demineralizer Installations,  
1937-55*

Anion Exchanger	Multiple Bed	Mixed Bed	Total
Weakly Basic	1,245	5	1,250
Strongly Basic	325	467	792
Total	1,570	472	2,042

In this way, for the first time, all salts were removed from water by chemical means. It is worth noting that, with modern improvements, the ion exchangers are still best suited for many applications.

It is apparent from Table 1 that the development of mixed-bed demineralization was due to the availability of strongly basic resins. The properties of these resins are illustrated in Fig. 1, which shows that the weakly basic resins form salts by simple addition, in contrast to the strongly basic resins which, like caustic, neutralize the weakest acids and therefore remove silica and carbon dioxide. Progressive degradation of strongly basic quaternary nitrogen groups to weakly basic amine form is now recognized as normal behavior which must be countered by conservative ratings and high annual replacement. At the bottom of Fig. 1 is shown reaction with an or-

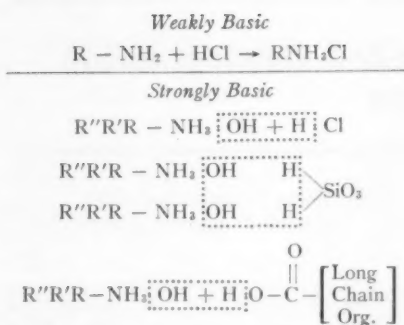


Fig. 1. Reactions of Anion-Exchange Resins

The weakly basic resins form salts by simple addition, in contrast to the strongly basic resins which remove silica and carbon dioxide by neutralizing the weakest acids.

ganic acid of high molecular weight, which is difficult to remove by regeneration and which thus causes organic fouling. These properties of anion-exchange resins are fundamental to the relative merits of multiple-bed and mixed-bed operation.

### Multiple-Bed Systems

Figure 2 illustrates the multiple-bed operation. The first unit, containing sulfonated coal or a high-capacity resinous cation exchanger, converts the calcium, magnesium, and sodium salts of the influent water to the corresponding acids. If required, carbonic acid can then be removed by vacuum or forced-draft degasification. In the last shell, a bed of highly basic anion ex-

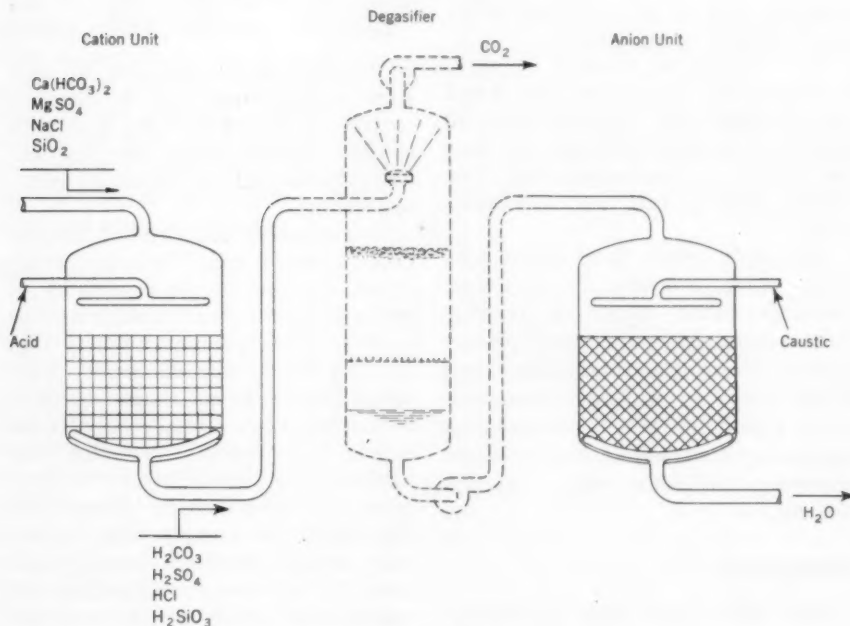


Fig. 2. Multiple-Bed Demineralizer

The degasifier, which removes carbonic acid, is not always required.

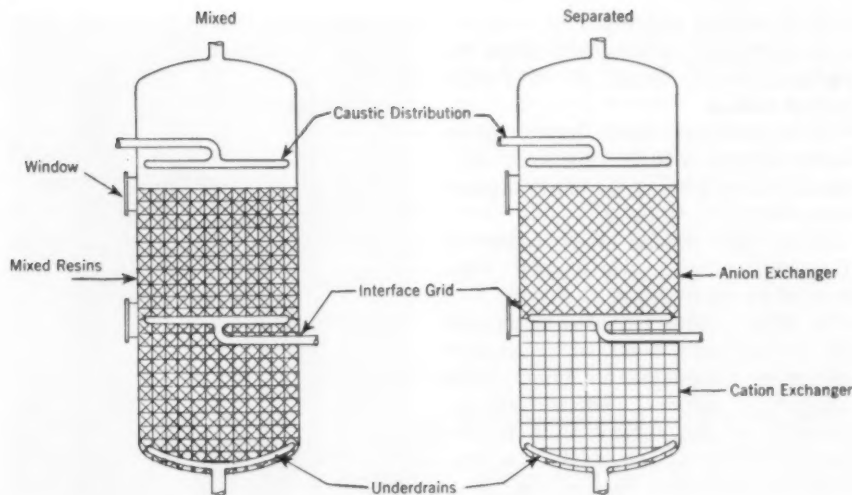


Fig. 3. Mixed-Bed Demineralizer

At the left, the resinous exchangers are intimately mixed. At the right is shown the exhausted bed after the resins have been hydraulically separated by backwashing.

changer neutralizes all acids and produces pure water. After exhaustion, the beds are backwashed. The cation exchanger is regenerated with acid and the anion exchanger with caustic, following procedures similar to the regeneration of simple sodium zeolite softeners.

### Mixed-Bed Systems

A mixed-bed demineralizer is diagramed in Fig. 3. At the left, the resins which were in separate shells in Fig. 2 are intimately mixed in the same vessel, so that each pair of particles furnishes an additional stage of water purification. At the right, the exhausted bed has been hydraulically separated by backwashing and the lighter anion resin is at the top, with a fairly sharp boundary at the interface between the two layers. The tank contains an additional interface grid through which is withdrawn caustic

used for regenerating the upper layer. Similarly, acid for regenerating the lower layer flows upward or downward between this grid and the underdrain. The separately regenerated resins are then rinsed and mixed with air, and are again ready for service. A section of an actual mixed-bed demineralizer is shown in Fig. 4.

### Performance

Figure 5 illustrates the performance of three multiple-bed and three mixed-bed demineralizers, selected for the widely diverse conditions of the water treated. The upper vertical bar graphs represent the analyses of the influent water. The types of water treated were:

1. A soft New England surface water which was high in organic matter

2. Baltimore city water
3. A highly mineralized, high bicarbonate well water at an Italian power station
4. A northern New Jersey public water supply which sometimes contained iron, manganese, and organic material
5. A high-sodium well water at Deepwater, N.J., which had been treated to remove iron
6. Water from the west branch of the Susquehanna River, which, because of mine drainage, contains large amounts of sulfates. The obvious superiority of the effluent from mixed-bed systems is shown by the low conductivity and silica data in Fig. 5.

At the Italian plant, sulfonated coal was used because of its better acid economy, and the low sodium leakage from this material is apparent in the low conductivity and silica in the effluent. The mixed-bed system at Deepwater, N.J., is preceded by acid zeolite units and degasification because of the high sodium and bicarbonate content of the water and the requirement for reducing silica to the lowest possible minimum.

The performance data of Fig. 5 by no means indicate limits attainable in each situation or necessarily the best type of operation. They do, however, represent proved design conditions of successful operating plants.

### Regeneration

Except for the inherent defects in resins, failure of instruments and control is the most prolific source of trouble in both multiple-bed and mixed-bed demineralizers.

The regeneration of a multiple-bed system with acid and caustic is almost identical to the regeneration of sodium

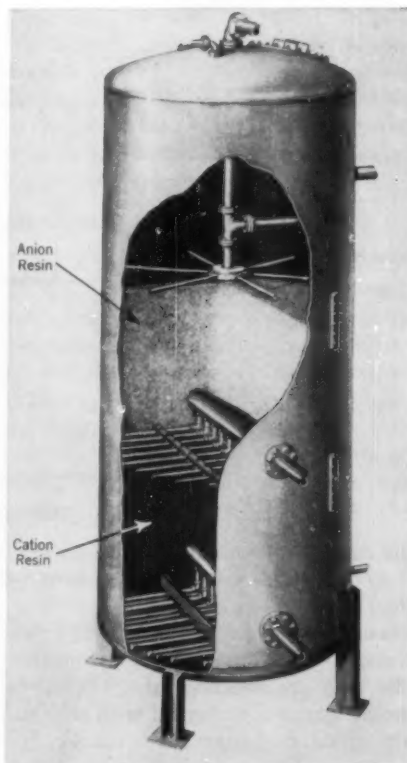


Fig. 4. Mixed-Bed Demineralizer

*The top feed device inside the tank is to distribute caustic, which regenerates the anion exchanger. (Equipment of Graver Water Conditioning Co., New York, is shown.)*

and hydrogen zeolites, with which water-conditioning engineers have been familiar for many years. Because the injection and rinse time is long and an exact routine is necessary, most of these systems are designed for automatic operation. Fig. 6 shows two demineralizer trains equipped with individual air motor-operated valves and a control panel for each system. Figure 7 shows a cation unit and an anion



unit equipped with single multiport valves actuated by several timers which are mounted in the small, dust-tight steel boxes on the front of each unit. The automatic controls shown in these photographs had already been developed to a high degree of dependability for sodium zeolite softeners when they were first utilized in demineralizing plants.

Regeneration of a mixed-bed demineralizer involves the successive

steps of backwashing, caustic injection and displacement, acid injection and displacement, partial draining, mixing with air, and rinsing. Unless each of these steps is carried out in exactly the right manner, serious performance failures may result. The automatic controls, therefore, must be much more complicated than those for multiple-bed systems.

Figure 8 is a schematic diagram of one type of control system. The influ-

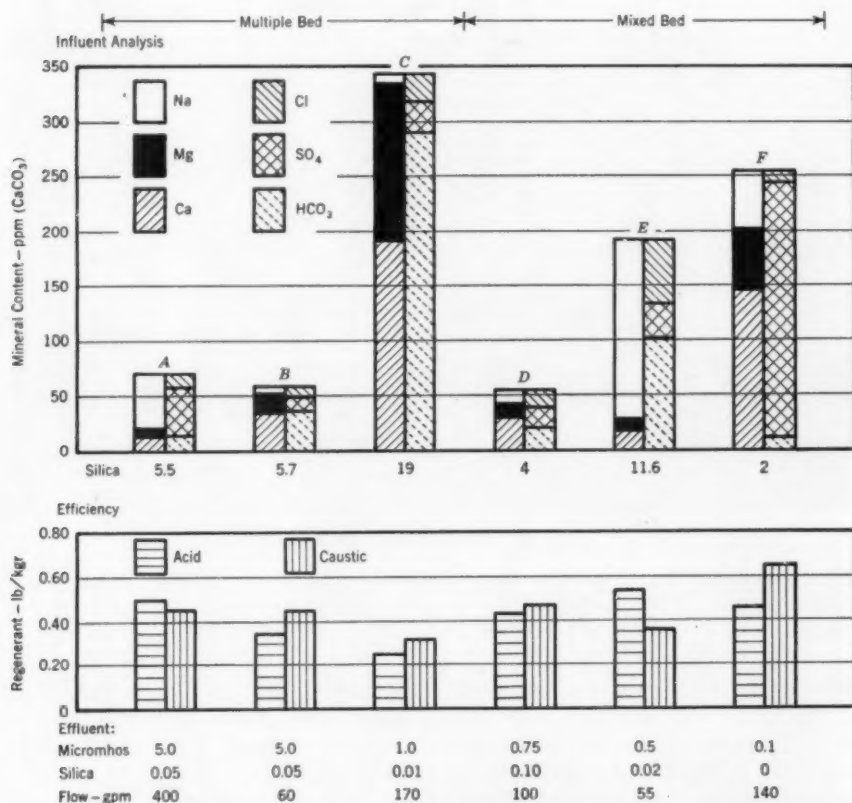


Fig. 5. Comparative Performance of Mixed-Bed and Multiple-Bed Demineralizers

The locations of these demineralizers are as follows: A—Millinocket, Me.; B—Baltimore, Md.; C—Piacenza, Italy; D—Passaic, N.J.; E—Deepwater, N.J.; F—Shawville, Pa.



ent, effluent, backwash, regenerants, rinse, and air are controlled by fifteen air-operated diaphragm valves. These are opened in sequence by the cycle-control disc of a pneumatic timer-transmitter covering the period of 240 min required for this operation. The

capacity and the water quality, these controls automatically carry out the regeneration of the unit. Figure 9 shows a control panel for two units. The position of all valves is indicated continuously by red and green lights on the flow diagram at the center of

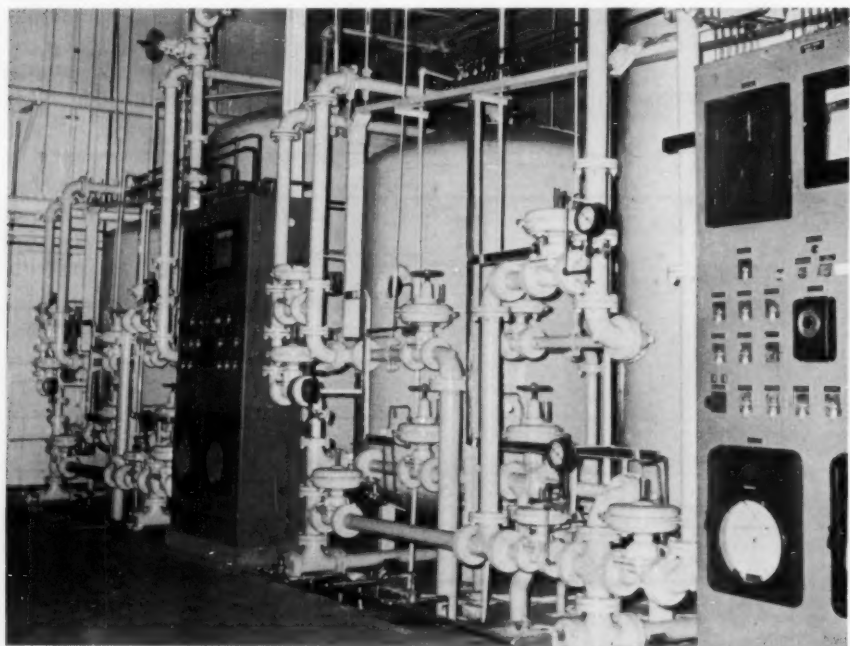


Fig. 6. Demineralizer Trains

*These two trains are equipped with individual air motor-operated valves and separate control panels. Most control systems are automatically operated because the process requires exact routine. (Equipment of Cochran Corp., Philadelphia, is shown.)*

specific flows required for backwash, displacement, and rinse are maintained by a flowmeter-controller with separate rate-setting, air-loading valves for each operation. Three auxiliary timers are required for functions not limited by the cycle-control disc. When the water meter in the influent line reaches a preset total based on the exchange

the panel. This system has been in operation for almost 18 months and the automatic controls are considered entirely successful (1).

Mixed-bed units may be equipped with multiport valves to direct the main streams through the upper and lower inlets to the shells and with auxiliary pilot valves to control the

flow of acid, caustic, and rinse water. Like the mixed-bed controls shown in Fig. 8 and 9, the instruments required for this system are numerous and complicated.

It should be obvious that both of these mixed-bed control systems include many potential causes of failure and require extensive routine maintenance. Although fully automatic, the regeneration is always carried out under supervision of an operator.

### Operating Difficulties

Case histories and descriptions of demineralizing installations usually discuss the successes met with, but only occasionally mention the failures. Nevertheless, both multiple-bed and mixed-bed demineralizing systems can go out of commission, and many of the causes of failure are widely recognized. A summary of operating difficulties may be helpful in avoiding some of them.

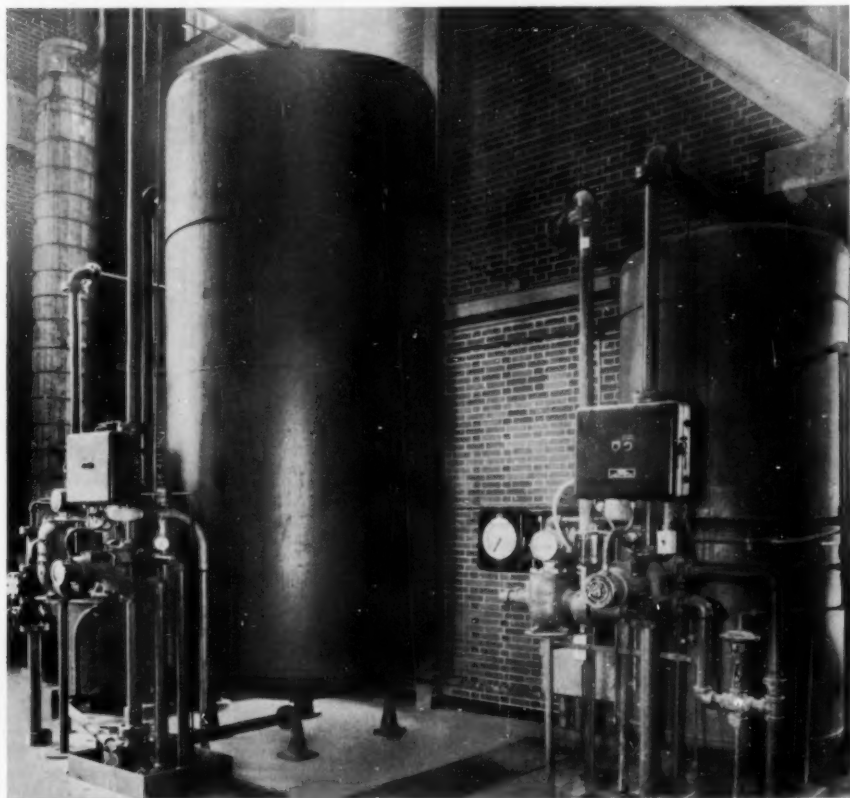


Fig 7. Multiple-Bed Units Equipped With Single Multiport Valves

*At the far left is the forced-draft degasifier. The cation unit is in the center and the anion unit is at the right. (Equipment of Permutit Co., New York, is shown.)*

The sources of trouble may be classified as resin capacity failures, instrument failures, and regeneration failures. All of these may be affected by material failures.

### Resin Capacity Failures

Resin capacity failures include loss in basicity of strongly basic anion-

plete failure of a mixed-bed unit to regenerate.

### Instrument Failures

Instrument failures are so numerous that any list is necessarily incomplete. The more troublesome include:

1. Failure of impulse counters to reset fully, resulting in a short count for the next operation

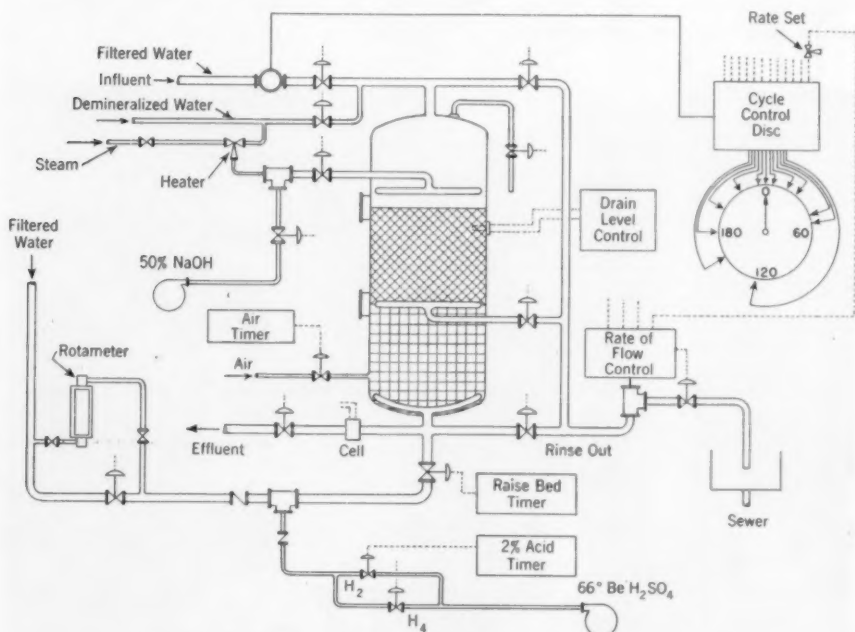


Fig. 8. Mixed-Bed Demineralizer With Automatic Controls

Fifteen air-operated diaphragm valves control the influent, effluent, backwash, regenerants, rinse, and air.

exchange resins (loss of silica-removal capacity), loss of total capacity, organic fouling, and coating with iron and other impurities. These are beyond the scope of this paper, and have been extensively discussed by Wirth (2). Thompson and McGarvey (3), Gilwood and others (4-7). Such difficulties may result in an excessively long rinse time, short capacity, or com-

2. Unscheduled impulses through contacts made by vibration

3. Missing impulses because of dust on contacts

4. False signal of high conductivity because of stagnant water in contact with cells

5. Faulty thermostatic control of caustic solution temperature.

### Regeneration Failures

Regeneration failures are traceable to difficulties in delivering regenerants in reproducible quantities, concentrations, and temperatures. They may be caused by deposits or corrosion which change the delivery characteristics of the regenerant pumps, piping, and control valves. Other failures relate to uncontrolled variations in water

cessive pickup of iron by hot concentrated caustic solution have occurred where bayonet heaters were used in caustic tanks and the lines were steam traced. Complete housing at normal temperature and avoidance of high metal temperatures in contact with caustic will correct this. Also, leakage of strong acid into water pipes, or of water into strong-acid pipes, where

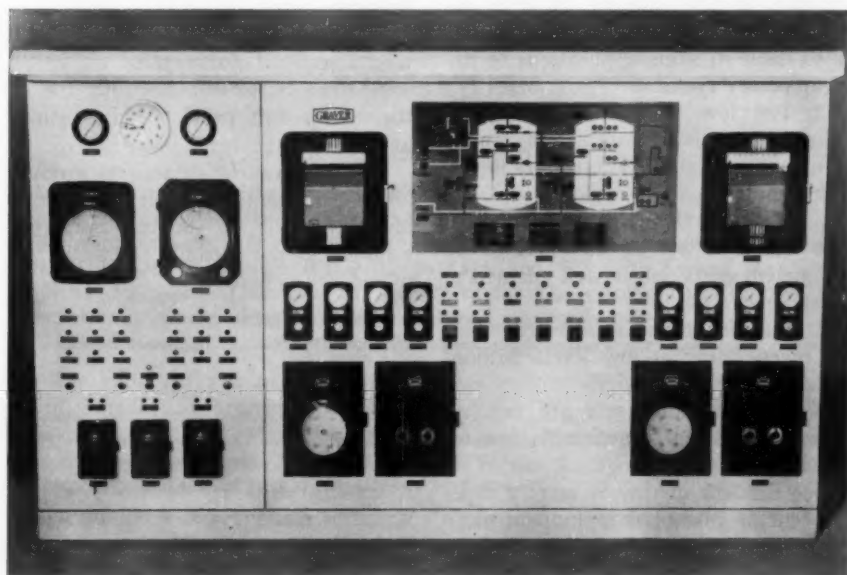


Fig. 9. Control Panel

*This panel controls two mixed-bed demineralizers. The flow diagram at the top of the panel indicates the positions of all valves. (Equipment of Graver Water Conditioning Co., New York, is shown.)*

pressure and air pressure. In general, pipeline mixing of regenerants and dilution water has been a major source of trouble and should be avoided wherever batch preparation is feasible.

### Material Failures

Material failures affect such items as rubber tank linings or metals in corrosive environment. Two cases of ex-

these liquids join at mixing tees, may bring dilute acid in contact with unsuitable metals. Positive dump valves to the sewer should protect all junctions subject to this type of trouble.

### Relative Merits

The foregoing discussion has brought out some of the strong and weak points of mixed- and multiple-

bed demineralizers but it may be helpful to summarize the advantages and disadvantages of the two methods.

Some advantages of mixed demineralization are:

1. This system results in an extremely high purity of effluent. Mixed-bed demineralizers can strip out from condensate the last traces of silica, soluble iron, and other salts, reducing the conductivity from 1.0 micromho in the influent to 0.05 micromhos in the effluent. This property is valuable in some applications to nuclear power cycles.

2. The low sodium leakage, solubilizing of colloidal silica, and control of effluent pH at 7.0-7.5, results in low silica content.

3. Complete demineralization within one vessel often effects savings in equipment costs and is well adapted to small flows.

4. Chemical costs are often reducible by regenerating at low levels without affecting effluent quality.

5. Rinse requirements are reduced because traces of regenerants are removed by ion exchange.

6. Effluent quality is largely independent of variations in influent quality, loss of resin basicity, organic fouling, and hydrolysis of resins when idle.

Disadvantages of mixed-bed demineralization are:

1. A major fraction of total plant capacity is out of service for regeneration or maintenance.

2. The regeneration process and controls are extremely complicated.

3. Mechanical degasification is impossible.

4. The system is vulnerable to contamination by iron, high hardness, or turbidity in the influent water. These

qualities would be removed in a multiple-bed system.

The advantages of a multiple-bed system are:

1. Regeneration is simple; controls, whose reliability has been proved by years of experience in zeolite-softening practice can be used.

2. Full-capacity flow can be maintained during regeneration if the size and number of units are selected properly.

3. Carbonic acid can be removed mechanically if warranted.

4. Removal of turbidity and iron by the cation unit protects the sensitive anion-exchange resin.

5. Cycles can be devised to produce an effluent containing very low solids and silica or to permit numerous economies not readily available in mixed-bed operation.

Disadvantages of a multiple-bed system are few. They are:

1. A multiplicity of tanks and regeneration operations is inherent in the design.

2. Small-flow plants are expensive if enough units are provided for the requisite standby and flexibility.

## Summary

More and more demineralizing systems are being installed, mostly for boiler feedwater treatment where silica removal is necessary. Mixed bed systems make an impressive showing numerically, but, in terms of capacity, they are probably not as large a factor as the figures suggest. In considering either system—the first consideration should be whether demineralization is really necessary. Further planning should then be toward the greatest economy, simplicity, and reliability.

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## Effects of Synthetic Detergents on Water Treatment

—J. C. Vaughn, R. F. Falkenthal, and R. W. Schmidt—

*A paper presented on Jun. 14, 1955, at the Annual Conference, Chicago, Ill., by J. C. Vaughn, Asst. Chief Water Chem. Engr., R. F. Falkenthal, Prin. Filtration Chemist, and R. W. Schmidt, Water Chemist, all of the South Dist. Filtration Plant, Chicago, Ill.*

**I**NCREASED use of synthetic detergents in the last decade has created a number of problems for the water treatment industry. Detergents, principally those used in households, pass with little change through the usual sewage treatment processes. Water sources that are subject to considerable re-use, therefore, can, in periods of low flow, accumulate an appreciable detergent content.

With the increase of reported difficulties in water utilities as a result of the use of detergents, the AWWA, in 1949, appointed a panel to discuss the problems involved in synthetic detergent pollution. Then, in 1953, when it was apparent that the difficulties created for water utilities by detergents were becoming too widespread and complex for individual solution, the AWWA Task Group E5.8 was formed to investigate the problem. Its first report was made in 1954 (1).

The task group, in beginning its work, made a survey of the entire continental United States and the province of Ontario, Canada. The purpose of the survey was to determine: to what extent there did exist problems created by the presence of detergents in water supplies; if, where there were problems, the amount of detergents present had been determined, and what methods of treatment had been effective in combating detergents. The task group

classified the involved problems as follows: [1] foam on settling basins, [2] taste and odor problems, [3] coagulation and sedimentation difficulties, [4] iron removal difficulties, [5] foaming of finished waters, and [6] quality deterioration in the distribution system.

### Experiences in England

The significance of the problems created by the use of synthetic detergents was recognized officially in England before it gained attention here. A committee on synthetic detergents was appointed on May 12, 1953, by the Minister of Housing and Local Government. The committee was directed "to examine and report on the effects of the increasing use of synthetic detergents and to make any recommendations that seem desirable with particular reference to the functioning of the public health service."

The interim report of this committee (2), dated Feb. 16, 1954, says in conclusion:

As already stated, our investigations will necessarily be lengthy. Some of the complicating factors involved are mentioned below; they make it particularly desirable that all generalizations about the effects of synthetic detergents should be treated with great caution.

a. The several types of synthetic detergent preparations have different prop-

TABLE 1  
*Evaluation Test on Carbon*

Sample	Carbon Added		Detergent Remaining ppm	Detergent Removed ppm	Detergent Removed per 1 ppm of Carbon Added ppm
	lb/mil gal	ppm			
1	0	0	20.0	0.0	0
2	100	12	14.0	6.0	0.50
3	500	60	5.4	14.6	0.24
4	1000	120	1.4	18.6	0.16
5	1500	180	1.1	18.9	0.11
6	2000	240	0.6	19.4	0.08

erties. If a particular type has any significant effect on sewage purification, it may be gradual and cumulative; its assessment is the more difficult in that, at any particular sewage works over a given period, . . . changes in the nature of the sewage or in the capacity and operation of the works may mask or falsify any effects of the detergents.

b. The active detergent materials used as a basis for the marketed preparations are not single chemical compounds capable of exact definition and analysis.

c. In marketed preparations the active detergent materials are accompanied by other substances that may extend or modify their properties and may themselves have properties relevant to this inquiry.

d. Accurate methods of determining small concentrations of synthetic detergents in sewage and trade effluents have still to be devised.

e. The scope for large-scale experimental work on synthetic detergents in relation to sewage and water treatment is limited by statutory and common law restrictions on river pollution and by the need to safeguard at all times the sewage purification and water supply services.

To sum up: Available evidence about the effects of the growing use of synthetic detergents does not justify any immediate alarm in users or the public health services. There is definitely nuisance at some sewage works, however, and there are other and more serious possibilities in relation to the efficiency of sewage treatment, the condition of rivers, and the

purity of water supplies. All these matters require and will receive most careful examination.

### Chicago Tests

The South District filtration plant in Chicago has carried out experiments on the quantitative evaluation of methods for removing detergents from water. Chemicals used in the tests were activated carbon, aluminum sulfate, ferrous sulfate, and chlorine dioxide. Other substances used were dolomitic limestone, bentonite, slaked calcium oxide, precipitated calcium carbonate, activated sodium silicate, finely divided silica sand, partially settled sediment from the settling basins in the filtration plant, and a primary rosin amine acetate. The testing materials were usually evaluated singly, but sometimes they were studied as a combination of two or more substances. The saturation point of recycled, settled sediment was determined and the effect of tripolyphosphate on coagulation was observed. In every case, 20 ppm of a commercial brand of detergent, which was considered 100 per cent anion active, was used. Six samples were prepared for each evaluation test. The samples were mixed for 30 min, allowed to settle for 15 min, and then filtered.

TABLE 2  
Data From Carbon Tests Arranged  
for Freundlich Equation

M Carbon Added ppm	X Detergent Removed ppm	$\frac{X}{M}$	C Detergent Remaining ppm
0	0	0	20.0
12	6.0	0.500	14.0
60	14.6	0.243	5.4
120	18.6	0.155	1.4
180	18.9	0.105	1.1
240	19.4	0.0808	0.6

The effectiveness of the chemical or substance for removing the detergent present was measured by means of the methylene blue chloroform-extraction method, with the samples being read on the colorimeter. The residual-

detergent values were plotted against the chemical dosages and curves were formed, as shown in Fig. 1 and 2. From these curves, the optimum removal of detergent was determined for each chemical applied.

### Carbon

In Fig. 1 it is seen that a dosage of 75 ppm of activated carbon, added to water containing 20 ppm commercial household detergent, will reduce the detergent to below 3.9 ppm, which is the critical point as found by Cross (3) and Culp (4). It is also apparent that dosages of activated carbon above 96 ppm effect little or no additional removal of detergent.

Results of these tests with carbon are shown in Table 1. In Table 2 the

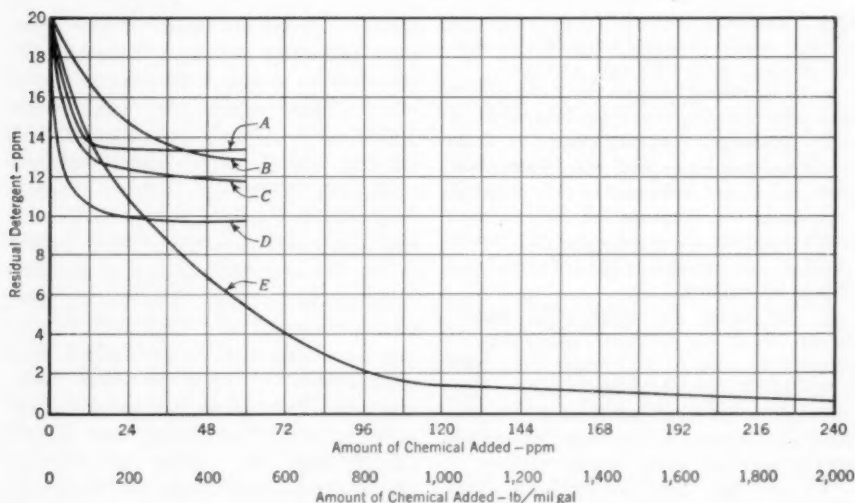


Fig. 1. Removal of Detergents by Various Chemicals

These curves, formed by plotting residual-detergent values against the chemical dosages applied, show the optimum removal of detergent for each chemical. The letters indicate the following: A—aluminum sulfate with pH of 8.8 (alum-silicate ratio 10:1); B—aluminum sulfate with pH of 8.4 (alum-silicate ratio 10:1); C—chlorine dioxide; D—ferrous sulfate; and E—carbon.

data have been arranged according to the Freundlich equation

$$\frac{X}{M} = K(C)^{1/n}$$

where  $X$  is the detergent removed,  $M$  the carbon added, and  $C$  the detergent remaining (1, 5). Figure 3 shows that the data fit the equation very well.

### Aluminum Sulfate

Aluminum sulfate and activated sodium silicate were used at a ratio of ten alum to one silicate. Tests were made with aluminum sulfate with pH 8.4 and pH 8.8. Lime water was added to maintain a constant pH value in each test. Results are given in Table 3 and 4. Fig. 1 shows that at a pH of 8.4 there is little effective removal at an alum dosage above 48 ppm and that the highest practical dosage is 42 ppm. At the optimum dosage of

42 ppm, 6.6 ppm detergent were removed. At a pH of 8.80 the highest effective dosage of alum is 16 ppm, and the highest practical dosage is 12 ppm. At this higher pH the alum-activated silica is more effective. At the optimum dosage of 12 ppm, 6.3 ppm detergent was removed.

### Ferrous Sulfate

Table 5 shows the results of the ferrous sulfate tests. Ferrous sulfate and chlorine were used at a ratio of 7 parts ferrous sulfate to 1 part chlorine, the chlorine being added to oxidize the ferrous sulfate. Lime water was added to maintain a constant pH value of 9.1.

As shown in Table 5, at the optimum dosage of 12 ppm of ferrous sulfate, 9.5 ppm detergent was removed. This is somewhat more effective than the alum-silicate coagulation, as can be seen from Fig. 1.

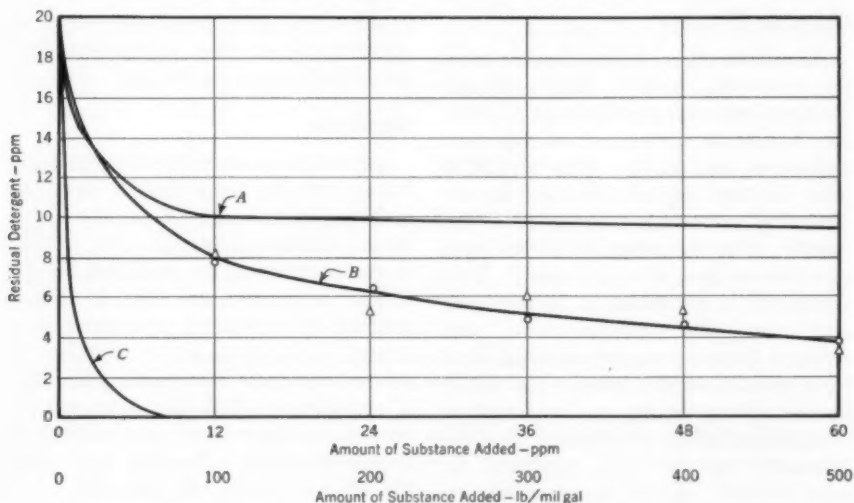


Fig. 2. Removal of Detergents by Various Substances

The letters indicate the following: A—bentonite; B—settled sediment (○ represents data from tests on alum-treated water, △ represents data from tests on lime-iron-treated water); and C—primary rosin amine acetate.

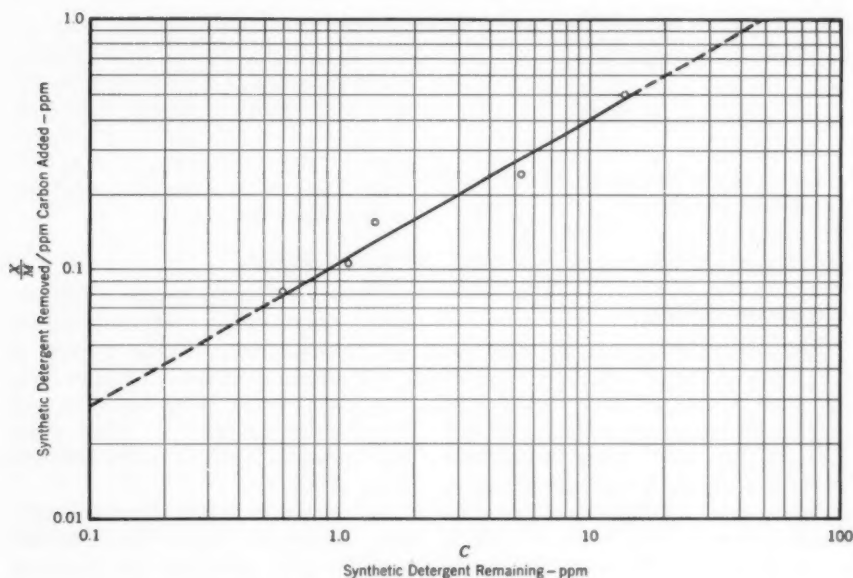


Fig. 3. Freundlich Equation Applied to Data From Carbon Tests

Data from the carbon tests, represented by  $\circ$ , fall close to a straight line.

### Chlorine Dioxide

Results of the chlorine dioxide tests are shown in Table 6. The optimum dosage of chlorine dioxide was 36 ppm. At that point a measure of the odor reduction was made. The threshold odor of the original sample was 14 (hot-dechlorinated). The odor of the sample after treatment with 36 ppm of chlorine dioxide was seven. This represents a reduction of 50 per cent and the odor characteristic was changed from a pungent, chemical odor to a musty, earthy odor. So much dechlorinating agent was required at this concentration of chlorine dioxide, however, that the agent produced an odor of itself. It was also necessary to dechlorinate the sample before determining the residual detergent by the methylene blue method, because the excess chlorine present would otherwise bleach the dye. In general, the by-

products of this treatment were so complex as to make it impractical at the high dosages employed.

### Bentonite

Bentonite was used with coagulation dosages of 10.7 ppm alum (90 lb per million gallons) and 1.8 ppm lime (15 lb per million gallons). The results of the tests are given in Table 7.

The bentonite, as Fig. 2 shows, reached its maximum adsorption at a dosage of 12 ppm, at which point 10 ppm of detergent were removed. This is equivalent to 0.83 ppm detergent removed for each part per million of bentonite added. Beyond this point the efficiency falls off markedly.

### Primary Rosin Amine Acetate

Primary rosin amine acetate was used with dosages of 10.8 ppm aluminum sulfate (90 lb per million gal-

TABLE 3  
*Evaluation Test on Aluminum Sulfate With pH 8.4*

Sample	Aluminum Sulfate Added		Detergent Remaining ppm	Detergent Removed ppm	Detergent Removed per 1 ppm of Alum Added ppm
	lb/mil gal	ppm			
1	0	0	20.0	0	0
2	100	12	16.6	3.4	0.28
3	150	16	15.7	4.3	0.27
4	200	24	14.7	5.3	0.22
5	300	36	13.6	6.4	0.18
6	500	60	12.9	7.1	0.12

lons), and 1.2 ppm activated sodium silicate (10 lb per million gallons).

A dosage of 10.8 ppm of primary rosin amine acetate reduced the 20 ppm detergent content to zero, as shown in Fig. 2. This primary rosin amine is a cationic material which has the property of neutralizing the anion-active material in the detergent so that it can be readily removed by the usual coagulating process. The use of bentonite in conjunction with this material aids the process of removing the detergent. The primary rosin amine is insoluble in water, but can be dissolved by adding a small amount of acetic acid, or it can be procured in the acetate form, which is water soluble. Although this material is effective in removing detergents from water, it unfortunately cannot be used. The primary rosin amine and its acetate form

are strong skin irritants and the manufacturer who supplied the particular samples used in these tests specifically recommends that they *not* be used in potable water supplies. A check on the ammonia content of the treated samples indicated that appreciable amounts of the rosin amine were left in the water after the reaction with the detergent. This is because the completion of the reaction requires that an excess of the rosin amine be present, making the use of rosin amine to remove detergent a remedy worse than the disease.

Since a discussion on the use of rosin acetate was presented before the Water, Sewage, and Sanitation Division of the American Chemical Society (6), the subject has attracted considerable attention among steam plant operators who have boiler-

TABLE 4  
*Evaluation Test on Aluminum Sulfate With pH 8.8*

Sample	Aluminum Sulfate Added		Detergent Remaining ppm	Detergent Removed ppm	Detergent Removed per 1 ppm of Alum Added ppm
	lb/mil gal	ppm			
1	0	0	20.0	0	0
2	100	12	13.7	6.3	0.52
3	150	16	13.3	6.7	0.42
4	200	24	13.3	6.7	0.28
5	300	36	13.3	6.7	0.19
6	500	60	13.3	6.7	0.11



TABLE 5  
Evaluation Test on Ferrous Sulfate

Sample	Ferrous Sulfate Added		Detergent Remaining ppm	Detergent Removed ppm	Detergent Removed per 1 ppm of $\text{FeSO}_4$ Added ppm
	lb/mil gal	ppm			
1	0	0	20.0	0	0
2	100	12	10.5	9.5	0.79
3	150	16	10.3	9.7	0.61
4	200	24	10.0	10.0	0.42
5	300	36	9.9	10.1	0.28
6	500	60	0.8	10.2	0.17

foaming troubles. Such problems with high detergent concentrations in boiler water are much more widespread than had been previously recognized. Because the steam plants are not concerned with the potability of the boiler waters, the use of the rosin amine acetate as an anti-foaming agent where detergents are involved may be worth trying.

#### Settled Sediment

Sediment from the settling basins was used, with alum dosage of 90 lb per million gallons and lime dosage of 15 lb per million gallons. The sediment, as removed in the daily basin-desedimentation process, was first allowed to settle for 1 hr. This settled sediment was used for the test. It was assumed to be 100 per cent active

material and to weigh 8.345 lb per gallon. Sediment from both alum-treated water and lime iron-treated water was used. Results from these tests are shown in Tables 9 and 10.

As can be seen in Fig. 2, sediment from water coagulated with aluminum sulfate, and sediment from water coagulated with chlorinated ferrous sulfate were equally effective in the removal of detergents. In either case a dosage of 60 ppm reduced the original 20-ppm detergent content to below the 3.9-ppm trouble-making level (3). Because this sediment is always available in relatively large quantities at any water plant, the rather high dosage requirement of 60 ppm is not too important. On the days that the sediment samples used in the tests were collected, the raw water treated with alum had a turbidity of 19 ppm.

TABLE 6  
Evaluation Test on Chlorine Dioxide

Sample	Chlorine Dioxide Added		Detergent Remaining ppm	Detergent Removed ppm	Detergent Removed per 1 ppm of $\text{ClO}_2$ Added ppm
	lb/mil gal	ppm			
1	0	0	20.0	0	0
2	100	12	12.9	7.1	0.59
3	200	24	12.2	7.8	0.32
4	300	36	12.0	8.0	0.22
5	400	48	11.8	8.2	0.17
6	500	60	11.8	8.2	0.14

TABLE 7  
*Evaluation Test on Bentonite*

Sample	Bentonite Added		Detergent Remaining ppm	Detergent Removed ppm	Detergent Removed per 1 ppm of Bentonite Added ppm
	lb/mil gal	ppm			
1	0	0	20.0	0	0
2	100	12	10.0	10.0	0.83
3	200	24	9.8	10.2	0.42
4	300	36	9.8	10.2	0.28
5	400	48	9.7	10.3	0.21
6	500	60	9.6	10.4	0.17

The alum dosage was 10.9 ppm (91 lb per million gallons) and the activated carbon dosage was 1.5 ppm (13 lb per million gallons). The chlorine dosage was 0.75 ppm (6.3 lb per million gallons). The raw water treated with chlorinated ferrous sulfate and lime had a turbidity of 13 ppm. The ferrous sulfate dosage was 8.3 ppm (69 lb per million gallons), the activated carbon dosage was 1.8 ppm (15 lb per million gallons), and the chlorine dosage was 0.73 ppm (6.1 lb per million gallons). The effectiveness and economy of this method of detergent removal make it well worth trying on a plant scale. Russell L. Culp, Water Supply Section Chief of the Kansas State Board of Health, has agreed to arrange plant-scale trials, if possible, at several small Kansas water plants that still have the detergent problem.

Further laboratory experimentation with settled sediment has indicated that, in recycling sediment in the same equivalent dosages, the sediment loses approximately 25 per cent of its detergent removal capacity with each cycle. This is true of the first, second, and third recycling. Projecting the results of these determinations, it is obvious that the fourth recycling would have practically no detergent removal capacity.

All of these experiments have been conducted with a commercial household detergent containing an alkyl sulfate and an alkyl benzene sulfonate as the surfactant materials. The colorimetric standards were prepared from the same commercial detergent. Further experiments showed that the settled sediment was as effective in removing from water surfactant ma-

TABLE 8  
*Evaluation Test on Primary Rosin Amine Acetate*

Sample	Primary Acetate Added		Detergent Remaining ppm	Detergent Removed ppm	Detergent Removed per 1 ppm of PRAA Added ppm
	lb/mil gal	ppm			
1	0	0	20.0	0	0
2	10	1.2	7.9	12.1	10.08
3	30	3.6	2.0	18.0	5.00
4	50	6.0	0.6	19.4	3.23
5	70	8.4	0.3	19.7	2.35
6	90	10.8	0.0	20.0	1.85

TABLE 9  
Evaluation Test on Sediment From Alum-treated Water

Sample	Settlable Sediment Added		Detergent Remaining ppm	Detergent Removed ppm	Detergent Removed per 1 ppm of Sediment Added ppm
	lb/mil gal	ppm			
1	0	0	20.0	0	0
2	100	12	7.9	12.1	1.01
3	200	24	6.5	13.5	0.56
4	300	36	5.1	14.9	0.41
5	400	48	4.6	15.4	0.32
6	500	60	3.8	16.2	0.27

terials that were 100 per cent alkyl sulfate and alkyl benzene sulfonate, respectively.

The question now arises as to why settled sediment is effective in detergent removal. The answer lies in an analysis of the results previously obtained. In Fig. 3 the data from the test on removal of detergents by activated carbon (*see* Table 1) have been plotted according to the Freundlich equation. These data fit the equation very well, and all the points fall close to a straight line. It is known that activated carbon is a finely divided porous material. Substances removed from water by activated carbon are presumably adsorbed onto its very great surface area. If the data from the settled-sediment tests (*see* Table 9 and 10) are arranged (*see* Table 11) and plotted according to the Freundlich equation, the points also fall close to a straight line, as shown in Fig. 4. Not only do the points fall on a straight line, but the points established by the data from both the alum sediment and the iron lime sediment fall close to the *same* straight line. This would indicate that the removal of anionic detergents from water by settled sediment is an adsorption phenomenon, and that the effectiveness of any material depends on the total surface available per unit of substance applied. The data from the alum-

activated silica and the chlorinated ferrous sulfate test, when plotted according to the Freundlich equation, also give a straight line. With these substances the slope of the lines is close to vertical. Robert Ingols (6) has pointed out that this characteristic indicates that the phenomenon is approaching a chemical reaction. Certainly the greater effectiveness of the alum activated-silica coagulation at a pH of 8.80 is due to the cationic action of the alum. That the removal of anionic detergents from water is generally an adsorption phenomenon is further confirmed by the fact that inert nonporous materials with limited total surface areas, such as finely divided silica sand and dolomitic limestone, are not at all effective. Some forms of precipitated calcium carbonate, which is a porous material with an appreciable total surface area per unit of material applied, are quite effective, however (12 ppm applied to 20 ppm anionic detergent in water removed 10.8 ppm detergent). Other forms are not at all effective. The effectiveness apparently depends on the relative amount of total surface area available.

Freundlich, in discussing the adsorption phenomenon, says "if a dissolved substance with increasing concentration, lowers the surface tension of a liquid relative to the gaseous space (which in the case of water bodies is

TABLE 10  
Evaluation Test on Sediment From Ferrous Sulfate-treated Water

Sample	Settlable Sediment Added		Detergent Remaining ppm	Detergent Removed ppm	Detergent Removed per 1 ppm of Sediment Added ppm
	lb/mil gal	ppm			
1	0	0	20.0	0	0
2	100	12	8.1	11.9	1.00
3	200	24	5.4	14.6	0.61
4	300	36	6.1	13.9	0.39
5	400	48	5.5	14.5	0.30
6	500	60	3.5	16.5	0.28

the air above) . . . then it will be concentrated at the interface (7).” This is borne out by the results reported from Wheeling, W.Va. (1) where the foam on the Ohio River showed a synthetic-detergent concentration of 3,800 ppm, whereas the highest synthetic-detergent concentration reported in the water itself was 12 ppm. Since the cleansing action of detergents is partly caused by their capacity to lower the surface tension

of the water, the difference in concentrations is a logical development. Since the function of both the anionic and the non-ionic detergents is the same, the removal of both types by the adsorption mechanism should be feasible.

A laboratory experiment was conducted on the removal of a nonionic detergent with settled sediment. Because the determinations of the non-ionic residues after treatment were qualitative, the results could only be estimated. Apparently the settled sediment adsorbed the nonionic material as readily as it did the anionic.

TABLE 11  
Data From Settled-Sediment Tests Arranged  
for Freundlich Equation

M Sediment Added ppm	X Detergent Removed ppm	$\frac{X}{M}$	C Detergent Remaining ppm
Alum-treated Water			
0	0	0	20.0
12	12.1	1.01	7.9
24	13.5	0.56	6.5
36	14.9	0.41	5.1
48	15.4	0.32	4.6
60	16.2	0.27	3.8
Iron-Lime-treated Water			
0	0	0	20.0
12	16.4	1.37	3.6
24	14.6	0.61	5.4
36	13.9	0.39	6.1
48	14.5	0.30	5.5
60	16.5	0.28	3.5

### Other Experiments

Other limited experiments were conducted on the problems created by the presence of detergents in water supplies. One of these was to determine the effect of low concentrations of detergent on the pH of the water. In distilled water, a detergent concentration of 20 ppm produced a pH which ranged between 5.5 and 7.0. One “built” detergent containing non-ionic surfactive compounds produced a pH of almost 7.8 at 20 ppm concentration, although another such detergent produced a pH which remained at about 5.6, up to a 20 ppm concentration. When plant tap water was used as the dilution medium, the pH

ranged from approximately 8.2 to 8.45, up to 20 ppm detergent concentration. This information is of interest only in estimating the general effect of detergents.

In the original investigation reported by Cross (3), two of the detergents investigated at the South District Filtration Plant were industrial base materials containing 100 per cent anion-active compounds. A recent test performed with lauryl sulfate showed

worse and interference with coagulation occurred. It is apparent that the surfactive compounds are at least partly responsible for the problems created by the presence of detergents.

A routine coagulation test was run on raw Lake Michigan water, with aluminum sulfate as the coagulant. The alum dosage was 10.5 ppm, or 90 lb per million gallons. The raw water turbidity was 2.2 ppm and the temperature was 55°F. Six jars were used

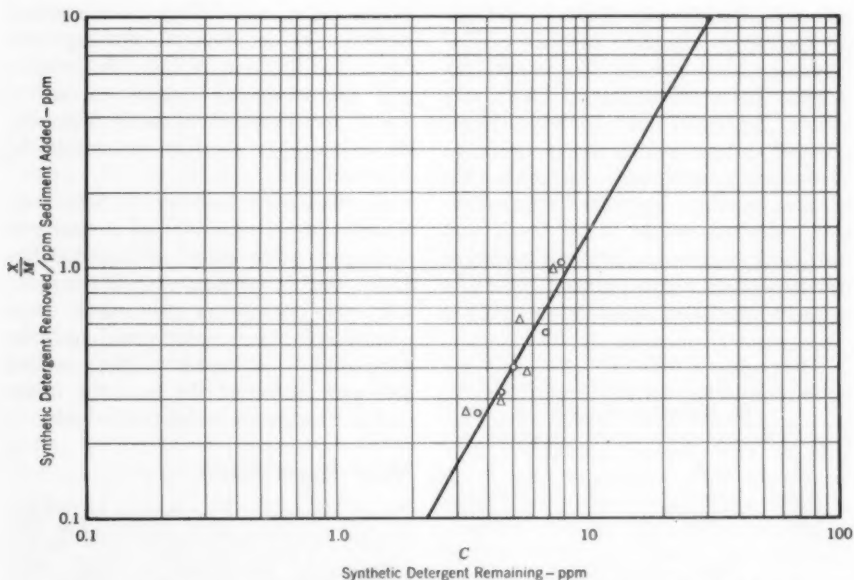


Fig. 4. Freundlich Equation Applied to Data from Settled Sediment Tests

Data from tests on alum-treated water, represented by O, and from tests on lime-iron-treated water represented by Δ, both fall along the same straight line.

that a concentration of 3 ppm in raw water gave an objectionable taste and odor. At 5 ppm the odor was very strong, foam occurred, and there was interference with coagulation. A parallel test was run using a 100 per cent non-ionic detergent base. Objectionable taste and odor were apparent at 1-ppm concentration in raw water. At 3 ppm, the taste and odor were

in the test, one of which was the control jar. To the other five jars, dosages of 1, 3, 5, 7, and 10 ppm tripolyphosphate were added. The time of stirring was 15 min, with the mixers rotating at 46 rpm. Floc was formed in all six jars at the end of 3 min. The floc in the control jar was "fair" while that in all five of the tripolyphosphate-treated jars was fine and

poorly formed. The turbidity of the settled water after 30 min was the same for all samples (3.6 ppm). The filtrate, filtered through a cotton plug, was clear for the control jar, but the filtrate from each of the tripolyphosphate-treated samples showed some colloidal turbidity. This turbidity ranged from 0.01 ppm for the 1-ppm tripolyphosphate-treated sample to 0.2 ppm for the 10-ppm tripolyphosphate-treated sample. It is apparent that tripolyphosphate does interfere with the alum coagulation of raw Lake Michigan water, even in concentrations as low as 1.0 ppm.

### Conclusions

As a summary of what has been discussed in this paper the following conclusions can be drawn:

1. The problems created by the presence of detergents in water supplies have been classified as follows: [1] foam on settling basins, [2] taste and odor problems, [3] coagulation and sedimentation difficulties, [4] iron removal difficulties, [5] foaming of finished water, and [6] quality deterioration in the distribution system.

2. Chlorine dioxide is effective to a limited degree in reducing the tastes and odors produced by detergents, but high dosages are required.

3. A cationic material, such as primary rosin amine, is effective but cannot be used in potable water supplies because it is a strong skin irritant.

4. Activated carbon is effective except that very high dosages are required and, beyond a certain point, it becomes ineffective.

5. Coagulation with aluminum sulfate, activated silica, and chlorinated ferrous sulfate is effective to a limited degree. The alum-silica treatment is most effective at a pH of 8.80.

6. Settled sediment, which has been concentrated by an hour's further settling, is most effective in removing detergents from water supplies. Sediment from treated water and lime iron-treated water is equally effective. After four cycles the sediment loses its capacity to adsorb surfactive substances.

7. Certain physical forms of precipitated calcium carbonate are effective to a limited degree.

8. A volcanic clay such as bentonite is effective to a limited degree.

9. Plotting the data from the carbon and settled-sediment tests according to the Freundlich equation indicates that the removal of detergents from water is a surface adsorption phenomenon. The results of the tests with bentonite and precipitated calcium carbonate confirm this.

10. The surfactive constituents of commercial detergents are partly responsible for the problems created by the presence of detergents in water supplies.

11. Tripolyphosphate interferes with alum coagulation in concentrations as low as 1 ppm in raw Lake Michigan water.

### Acknowledgments

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### Discussion

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The authors have reported important information on the effects of synthetic detergents. A number of points deserve emphasis, however.

The first deals with the build-up or accumulation of detergents in reused waters. Many questions remain concerning the extent to which the several types of detergent compounds are removed or decomposed by waste treatment. It is generally agreed that the alkyl aryl sulfonates (which represent approximately 43 per cent of the capacity of synthetic detergent plants in the United States) are resistant to biological oxidation. On the other hand, the alkyl sulfates (which represent 12 per cent of the capacity of United States plants) are apparently broken down readily by biological activity. Little is known of the removal of these substances by other natural purification forces. The facts noted, however, should emphasize the impossibility of relating detergent concentrations in raw water to the per capita use of detergents upstream.

A second point is that care must be taken to be more specific in identifying the source and type of detergent sub-

stances used in experimental studies. This is necessary because the commercial synthetic detergents represent a mixture of one or more chemical types of surface-active substances, several compounds serving as builders, and contaminants or fillers or both. The effect of detergents on water treatment must be studied in terms of the influences of the specific surface-active substances and of the various other compounds. The isolation or separation of the effects of the individual substances should be followed by the study of the effect of combinations. This is the only way in which the needed information can be accumulated, evaluated, and applied to the solution of particular water treatment problems.

A third point is that a more uniform and rational basis must be taken in the future in reporting detergent concentrations. The percentage of surface-active ingredient varies from one packaged commercial product to another, and very probably, although to a lesser extent, from one package to another of a given product. Let it be assumed that a colorimetric calibration curve, prepared from a packaged commercial product, is used to estimate the concentration of detergent in a raw water sample. If the results are reported in terms of equivalent commer-

cial product, an error is introduced by the fact that the ratio

packaged synthetic detergent  
surface active substance

was not the same for the sample as it was for the standard solutions. Because present analytical methods measure surface-active substances, it seems logical to express concentrations in terms of these compounds. Unless such a basis is adopted, misunderstanding is certain to result, with no possibility of comparing results from one laboratory with those of another.

The fourth point is that studies, such as those which are being carried on at the Robert A. Taft Engineering Center, Cincinnati, Ohio, must be made in order to establish the specific effects of the widely used poly and pyrophosphate builder compounds. What proportion of the synthetic-detergent effects is caused by the typical surface-active substances and what part by the phosphate builders is a question which needs investigation.

A fifth point questions the wisdom of overemphasizing the significance of, or placing too much reliance on, many of the detergent levels which have been reported. Most of these values have been in terms of the equivalent packaged product, which is related to surface-active ingredient by a factor that varies from one raw water source to another. Furthermore, there are analytical difficulties stemming from the fact that certain organic substances give false color. The acceptance of 3.9 ppm (package basis) as the level at which detergents begin to interfere with coagulation, for example, is dangerous practice. Both the Taft laboratories (1) and Laneglier (2) have reported considerably higher levels. Also, this value might vary from one

source to another, depending on raw water quality and the type and amount of builder compounds involved, as well as on the method of coagulation used.

Adsorption of the large, negatively charged detergent ion appears to be the most sound method of removing detergent substances from water. Adsorption, on both active carbon and on alum floc, might be more effective at lower pH values than those used at Chicago's South District Filtration Plant. The carbon might be more efficient and the floc might be positively charged at the lower pH.

The possibility of a reaction between chlorine and the various synthetic detergent constituents has been explored by a number of people, including Culp and Stoltenburg (3), Filicky (4), and Vaughan (5). In the laboratories at Cornell, W. A. Bundy has studied, under carefully controlled conditions, the reaction between chlorine and an alkyl benzene sulfonate type of detergent (6). The source of this compound was a reference standard containing 41 per cent active ingredient, with sodium sulfate and sodium chloride making up the remainder. Concentrations of surface-active substance up to 10 ppm were allowed to react with chlorine concentrations as high as 10 ppm in distilled water buffered at pH 7. The reaction periods were 2 and 24 hr long, with and without 1 ppm ferric ion. The reactions were run in subdued light, at 23°–25°C. Residual chlorine and residual surface-active substance were measured by the amperometric titration and the two-phase titration methods, respectively. All analyses of residuals were in triplicate and were paralleled by analyses of corresponding control samples.

Statistical analysis of the data makes it possible to state with almost com-

plete confidence that there was no chlorine demand and no destruction of alkyl benzene sulfonate during a 24-hr period. A small chlorine demand (0.5–1.0 ppm) and partial destruction (10–20 per cent) of the surface-active substance occurred during a 120-hr period.

These results appear to bear out the prediction that compounds of this type are very difficult to chlorinate under ordinary conditions. Studies show no evidence that the amounts of surface-active substance actually present in raw waters would increase the chlorine demand of the water.

The Dept. of Sanitary Engineering at Cornell University, in research sponsored by the National Institutes of Health, is currently investigating the effect of synthetic detergents on rapid sand filtration. During the first phase of this work two lines of approach have been pursued. The first has resulted in simulating a heavy accumulation of a surface-active substance on filter sand and in measuring the effect of this coating on filter performance, by means of a hydrophobic stearate coating. The second line of approach resulted in measuring the effect of a specific surface active agent

(an alkyl benzene sulfonate) on sand filter performance, as distinct from its effect on coagulation. This was accomplished by introducing varying amounts of the compound to the coagulated and settled influent of a test filter, while the same influent without the detergent was put on a control filter.

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## Effects of Synthetic Detergents on Rapid Sand Filter Performance

—Lawrence H. Sanford and Charles D. Gates—

*A contribution to the Journal by Lawrence H. Sanford, Instructor in San. Eng., and Charles D. Gates, Assoc. Prof., School of Eng., both of Cornell University, Ithaca, N.Y.*

**N**UMEROUS instances of adverse effects of synthetic detergents on water and waste treatment processes have been observed and reported. A limited number of laboratory studies also have been carried out and the bulk of the information obtained has been compiled in a report by an AWWA task group (1) and in a review by Smith, Walton, and Cohen (2).

Experience with, and studies of, detergents in water treatment practice have dealt almost entirely with their effect on coagulation, settling, and taste and odor. Concentrations as low as 4 to 5 ppm (packaged-detergent basis) have been described as interfering with coagulation and settling (3, 4), although laboratory studies have shown such effects only at much higher levels (5, 6). The only place where detergents were reported to have had an effect on filtration was in Osawatomie, Kan., where a reduction in filter runs from 100 to 9 hr was attributed to detergents in the raw water (3).

### Present Study

The study described in this paper was undertaken for the purpose of evaluating the effect of surface-active agents on the performance of rapid sand filters. The study was performed in such a way as to measure the direct effect of these agents on the filtration

process itself, as distinct from their indirect effect on filtration resulting from interference with coagulation and settling. It was also possible to simulate a hypothetical accumulation of a surface-active substance on filter sand and to measure its effect on filter performance.

It was, and is, considered essential that the effects of synthetic detergents on water treatment processes be measured in terms of influence of the various components—specific surfactants and specific builders. The present research, therefore, was concerned with the effect of an alkyl benzene sulfonate-type surfactant which was free of any phosphate-type builder.

The terms "surface-active agent" ("surfactant") and "synthetic detergent," as used in this paper, are in accordance with the definitions of the task group (1).

### Theoretical

Surface-active substances could influence filter performance either directly or indirectly—that is, as a result of either adsorption on the filter media surfaces or adsorption on the primary turbidity or alum floc particles. It was felt that the effect of surfactants on sand filters could best be explained in terms of interactions between these substances and the sand, floc, and bac-

terial surfaces. A considerable knowledge of the nature of these surfaces was gained, and interactions were postulated. The bulk of this information has been presented elsewhere (7).

The alkyl benzene sulfonates (ABS) represent the predominant type of surface-active substance used in the production of packaged synthetic detergents in this country (8). These anionic surfactants are fully ionized at the concentrations anticipated in water supplies, yielding large, negatively charged ions. Aluminum oxide floc consists of coagulated colloidal particles positively charged at pH of less than 7.5. Clean sand surfaces are negatively charged, polar, and hydrophilic. Clay turbidity particles are also negatively charged.

In terms of the electrostatic forces of adsorption, the surfactant anion should be strongly adsorbed on the oppositely charged floc, and only weakly or indirectly on the sand surfaces. Adsorption of surfactant on the floc or on the clay turbidity particles might change the settling characteristics as well as the filterability of the floc. Such adsorption would reduce ABS concentration of the water.

Although it is much less likely than adsorption onto the floc, the possibility of the adsorption of ABS onto the clean sand cannot be ignored. The polar surfactant ion is attracted to the polar sand. Vaughn (*this issue*, p. 30) demonstrated the adsorption of ABS on bentonite. Since silicate clays and quartz sands have surface forces of similar magnitude, adsorption of ABS on sand could occur. No large accumulation of anionic surfactant on clean filter sand is to be expected, since adsorption is ordinarily governed by the laws of chemical equilibrium.

The whole picture may be considerably changed by the presence of floc or

calcium carbonate which often accumulates on the sand surfaces. The adsorption of anionic surfactants would be greater on coated than on clean sand.

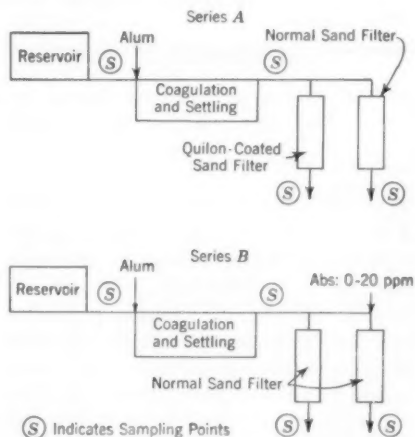


Fig. 1. Schematic Flow Diagrams

The flow diagrams show the test conditions used in the two series of filter runs. The pretreatment of sand, alum dose, detergent dose, and dissolved-oxygen content of water were varied in the tests.

The accumulation of a surfactant on clean sand, or on floc or calcium carbonate-coated sand, would result in a nonpolar, hydrophobic coating instead of the normally polar, hydrophilic surfaces. This condition can be simulated by the application of Quilon,\* a stearato chromic chloride, to produce a hydrophobic stearate coating on the sand (9). The presence of this coating should also give an indication of the role of adsorptive forces in the removal of alum floc and bacteria by sand filters. If adsorptive forces are significant here, the removal of both aluminum and bacteria should be less with Quilon-coated sand. Similarly,

\* A product of The Du Pont de Nemours Co., Wilmington, Del.

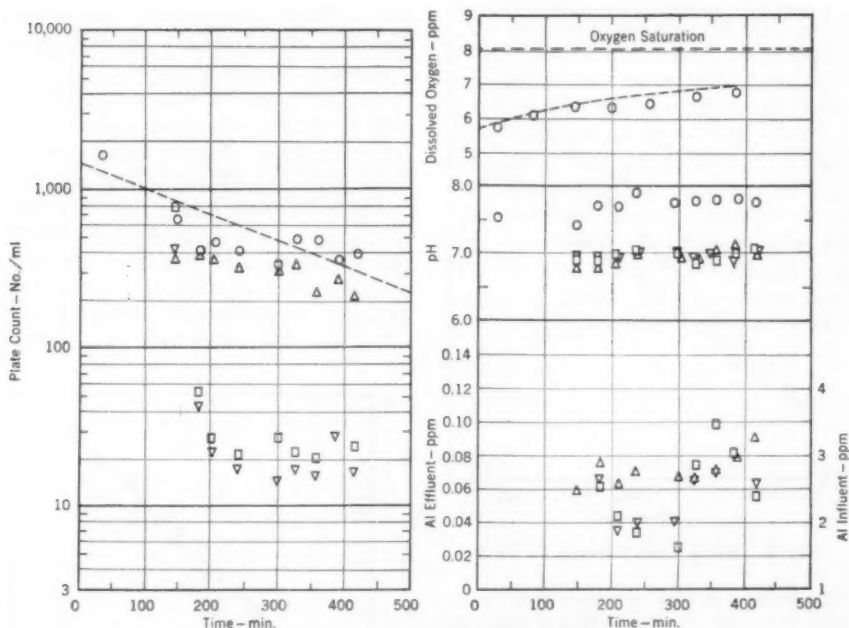


Fig. 2. Representative Effluent Quality Data

The symbols used represent data for the following:  $\circ$ —plant influent;  $\triangle$ —filter influents;  $\square$ —test filter effluent;  $\nabla$ —control filter effluent. "Al Effluent" and "Al Influent," at bottom right, refer to the parts per million of aluminum in effluent and influent, respectively.

this hydrophobic coating should indicate whether or not the air-water contact angle on sand has any influence on air binding in filters. A clean sand has a low contact angle with water, whereas a stearate Quilon-coated sand has a contact angle of almost 90 degrees.

### Experimental Methods

Two series of filter runs were made, totaling 21 runs altogether. Such factors as pretreatment of sand, alum dose, detergent dose, and dissolved-oxygen content of the water were varied in the experiment.

A model rapid sand filter plant was set up to include the following units: [1] a 65-gal aluminum tank from which

the synthetic raw water was admitted to the plant during the run, [2] a mechanically agitated, rectangular mixing tank, with compartments for rapid and slow mixing, [3] calibrated glass nozzles for adding alum and detergent solutions at dropwise rates, [4] a rectangular settling tank, and [5] 72-in. long glass tubes of 2½-in. diameter, fitted with perforated-plate funnel bottoms. Flow through the entire plant was by gravity, with the rate of flow controlled by a needle valve and a rotameter in the effluent line of each filter. A schematic diagram of model sand filters is shown in Fig. 1.

A synthetic raw water was prepared by the addition of calcium, magnesium, and sodium salts, plus the desired vol-



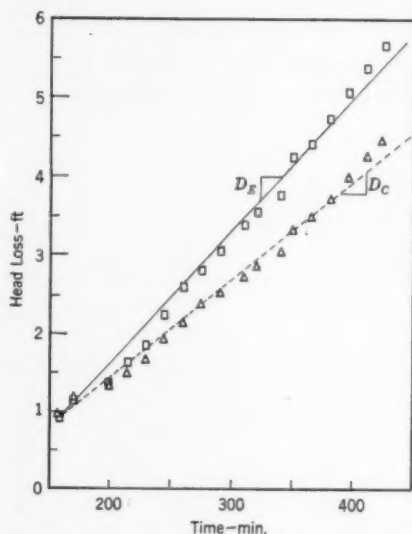


Fig. 3. Head Loss Related to Time

Data from test filter are indicated by  $\square$ . Data from the control filter are indicated by  $\triangle$ . Test filter influent was deaerated and contained 10 ppm alkyl benzene sulfonate. (Run 20).

#### Typical Sieve Analysis

Sample	Percentage Retained on or Between Sieve No.:					
	14	14-20	20-28	28-40	40-48	Pan
ABS	6.6	19.9	44.8	26.5	2.0	0.2
Control	6.6	21.4	44.8	25.6	1.6	0.2

ume of an 18-20 hr American Type Culture Collection *Esch. coli* broth culture, to a previously deionized and deaerated tap water. This gave a water with a hardness of 100-110 ppm as  $\text{CaCO}_3$ ; an alkalinity of 70-80 ppm as  $\text{CaCO}_3$ ; a pH of 7.5-7.8; and a plate count of 1,000-4,000 per ml.

The use of a synthetic raw water containing no turbidity eliminated from the system a variable which has little bearing on the studies and which is

very difficult to measure accurately. Bacterial densities are equally good criteria of filter performance and can be more accurately estimated analytically than can turbidities. The use of synthetic water assured that plant influent would be the same for each run.

The filter sand was a medium sand which had been hydraulically mined and processed. It was 99.5 per cent  $\text{SiO}_2$  and had an effective size of 0.5 mm and a uniformity coefficient of 1.48. It was considered a "sharp"

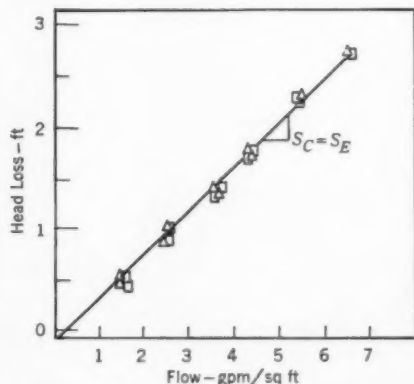


Fig. 4. Head Loss Related to Flow

The samples used were the same as those in Fig. 3. Column height of the test filter was 25.8 in., and column height of the control filter was 25.2 in. The porosity for both sand columns was 42.4 per cent.

sand (10). Fresh sand was used for each filter run to make sure that there would be no residual effects remaining from previous runs.

The surfactant used was a polypropylene benzene sulfonate (ABS) reference material containing 41 per cent surface-active material with  $\text{Na}_2\text{SO}_4$  and  $\text{NaCl}$  as the principal impurities. The material was phosphate free. All values are reported as parts per million of ABS.

Preparation of paired filters (test and control) for each run included: [1] placing 2,500 g of sand over 200 g of torpedo sand, followed by 10-15 min of backwashing to give a clear wash; [2] tapping the filter 100 times to insure reproducible compaction; and [3] measuring head loss versus flow relationships to ensure as nearly identical hydraulic properties of the clean filters as possible. Pairs showing significant differences were dis-

At the start of each run the filters were bypassed for a fixed period, during which raw water was dosed, coagulated, and settled until it was ready to be admitted to the filters. During the same period the filters were rinsed until there was no chlorine residual. After admission of the settled water, the filters were continuously operated in parallel at a 2-gpm per square foot rate until either the raw water was gone or the available head losses had

TABLE 1  
Summary of Filter Runs

Run No.*	Sand Treatment	Water De-aerated	Esch. coli Added	Alum Added ppm	ABS Added ppm	Head Loss v. Flow ft./gpm/sq ft		$S_F$ $S_C$	Head Loss v. Time ft./min $\times 0.01$		$D_F$ $D_C$
						$S_F$ Test Slope	$S_C$ Cont. Slope		$D_F$ Test Slope	$D_C$ Cont. Slope	
6	Quilon	no	yes	43		0.400	0.400	1.000	1.675	1.500	1.117
7	Quilon	not									
8	Quilon	no	yes	34		0.510	0.510	1.000	1.945	1.512	1.286
9	Quilon	no	yes	34		0.630	0.630	1.000	2.48	1.485	1.670
10	Quilon	no	yes	34		0.674	0.636	1.060	0.515	0.405	1.272
11	Quilon	not									
12	Quilon	yes	yes	34		0.768	0.730	1.052	1.050	0.810	1.296
13	none	yes†	no	34		0.466	0.430	1.084	1.145	1.045	1.096
14	none	yes†	no	34		0.494	0.472	1.047	0.825	0.825	1.000
15	Quilon	yes	yes	34		0.506	0.476	1.063	1.415	1.270	1.114
19‡	none	yes	yes	34	20	0.362	0.392	0.923	1.700	1.140	1.491
20	none	yes	yes	34	10	0.436	0.436	1.000	1.700	1.290	1.318
21	none§	yes	yes	34	5						
22	none	yes	yes	34	5	0.474	0.494	0.960	1.201	0.860	1.402
23	none	yes	yes	68	3	0.470	0.500	0.940	1.075	1.025	1.049
24	none	yes	no	34							
25	none	yes	yes	34	3	0.530	0.530	1.000	1.040	1.040	1.000
26	none	no	no	34	3	0.436	0.408	1.068	0.747	0.680	1.098
30	none	no	no	34	10	0.474	0.474	1.000	1.585	1.170	1.350

\* Results from Runs 1-5 were not considered valid because of inadequate control over hydraulic properties of paired filters. No alum was used in Runs 16-18 and they are omitted.

† Tap water used instead of simulated raw water.

‡ Abnormally high pH resulted in precipitation of  $\text{CaCO}_3$  and  $\text{Mg}(\text{OH})_2$ .

carded. At this point, in runs where Quilon was applied to the test filter, both sand columns were removed. The Quilon was applied by shaking the sand vigorously for 15 min in 2 liters of neutralized, 1 per cent Quilon. This was followed by 24-36 hr of drying at 225°F. The control sand was given the same shaking and drying. The treated sands were replaced in the filter tubes, head loss versus flow was rerun, and the filters were chlorinated overnight.

been consumed. Alum- and ABS-dosage drop rates, filter-flow rates, and head losses were recorded every 15 min, and the rates were corrected where necessary. Samples for bacterial and chemical analyses were collected on raw water, settled water, and filtered water according to a fixed-time schedule. The sampling schedule was weighted to place greater emphasis on the filter effluents, because these differences were the most significant ones. Twenty-one valid runs were made, in-

cluding three control runs. Typical observed data are plotted in Fig. 1-4. Table 1 describes the runs and summarizes the head loss results.

It was decided that the effect of surfactants on filter performance could best be measured by comparing the effluent quality and head loss increase rate for pairs of test and control filters operated in parallel. Such a comparison is valid only when two conditions are rigorously established and constantly maintained. The first is that there be a common influent with constant or controlled bacterial and chemical characteristics. The second is that the sand columns in the test and control filters must have identical or nearly identical hydraulic characteristics. The first condition was readily met by the application of a common coagulated and settled influent to a parallel pair of filters. The use of a control filter for each run compensated for the variations in the floc characteristics of the settled water. These variations from run to run, as well as during runs, were inevitable, even with careful control of the raw-water quality.

Since a comparison of the rates of increase in head losses was considered highly significant in evaluating the effect of various treatments, it was necessary to measure, for each pair of filters or run, any differences in their hydraulic characteristics, such as sand size, shape, or porosity, which might of themselves cause differences in the rates of increase of head losses. Three full length runs—13, 14, and 24—were made to establish for filter pairs the relationship between the rate of increase of head loss versus time, caused by differences in sand properties, and the head loss versus flow characteristics. Theoretically, this pro-

cedure resulted in the elimination of all variables except the treatment under consideration, provided that the differences in the hydraulic properties of the test and control filters could be corrected.

The method of correction was based on results of the three control runs. The slopes of head loss versus flow (plotted in Fig. 4) were designated as  $S_E$  and  $S_C$ ; the slopes of head loss

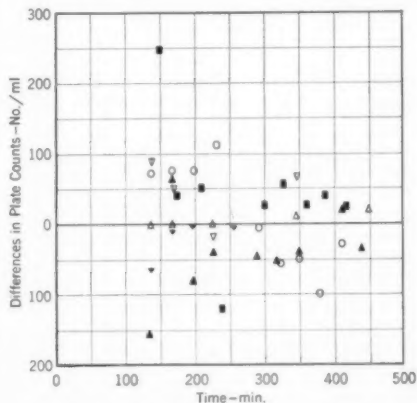


Fig. 5. Differences in Plate Counts of Filter Effluents

The values were determined by subtracting plate count for control-filter effluent from that for Quilon coated-sand filter effluent. Symbols used indicate data from the following tests:  $\triangle$ —Run 6,  $\nabla$ —Run 8,  $\blacktriangledown$ —Run 9,  $\blacktriangle$ —Run 10,  $\blacksquare$ —Run 12, and  $\circ$ —Run 15.

versus time (plotted in Fig. 3), and  $D_E$  and  $D_C$ , where the subscripts  $E$  and  $C$  refer to test and control filters respectively. The use of the ratio  $D_E/D_C$  eliminated run-to-run differences in floc properties of filter influent as a variable. The ratio  $S_E/S_C$  was plotted against the ratio  $D_E/D_C$  for the three control runs. A linear least-squares line of best fit was put in and designated as the correction line. Ninety-

per cent confidence limits about this line, necessarily passing through the origin, were plotted.

In finding the correction line for hydraulic properties, the ratio of  $S_E$  to  $S_C$  was assumed to vary linearly with the ratio  $D_E/D_C$ . The slope of the least-squares line at 90-per cent confi-

Runs 25 and 26, and Runs 20 and 30, to be pairs of duplicate runs. The 90-per cent confidence limit for any single run has been plotted, in Fig. 9, to the right of the confidence intervals on the line of correction.

It is reasoned that single runs will fall to the right of the Line *D* in Fig. 9 only as a result of the test treatment, and not as a result of random differences.

### Discussion

Comparison of effluent qualities was made by taking the algebraic differences of the average of replicate determinations. If these differences bracket or average zero, there is no significant difference in the effluent quality.

There is nothing in the data shown in Fig. 5 and 6 to indicate that the hydrophobic coating had any effect on removal of aluminum or of bacteria. Even though the differences in filter effluents plotted may appear to show a trend for individual runs, no such trend is apparent when values for all the runs are considered. Table 1 and Fig. 9 indicate that in every run where stearate-coated sand was compared with a normal sand, the former showed a higher rate of increase of head loss in the presence of alum floc.

Runs 6, 8, 9, and 10, with super-saturated water, all fall to the right of the 90-per cent confidence line shown as Line *D* in Fig. 9, while Run 15, with undersaturated water, falls to the left. These data suggest that, for a water supersaturated with air, there is significantly more air binding in the Quilon-sand filter than in the control-sand filter. This is in agreement with the theory that since a hydrophobic coating increases the air-water contact angle, it increases bubble formation. Also in agreement is the fact that Runs

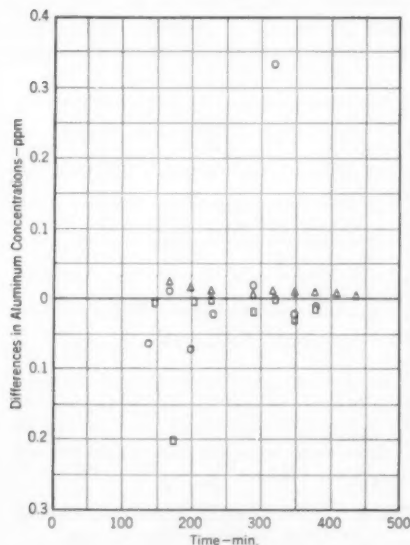


Fig. 6. Difference in Aluminum Concentrations of Filter Effluents

The values were determined by subtracting the concentration for control-filter effluent from that for Quilon coated sand-filter effluent. Symbols used indicate data from the following tests:  $\Delta$ —Run 10,  $\square$ —Run 12,  $\circ$ —Run 15.

dence was  $0.9984 \pm 0.0682$ , which seems to substantiate this assumption. The lines are shown in Fig. 9.

The confidence interval of any single run was estimated by fixing the ratio  $S_E/C_C$  and measuring the variance of  $D_E/D_C$ . The variance of  $D_E/D_C$  was estimated by assuming the three control runs to be replicates, and assuming

6, 8, and 9, with increasing levels of supersaturation, showed increasingly greater statistical significance. Hence, both theoretical and experimental considerations lead to the conclusion that the stearate coating interferes with filter performance only in terms of increased air binding, and that adsorptive forces are not a major factor in the removal process. If the floc par-

factant solution in the test filter influent.

Results in Fig. 7 and 8 indicate that the addition of as much as 20 ppm of ABS to the filter influent had no adverse effect on the removal of aluminum and bacteria by the filter.

Table I and Fig. 9 indicate that concentrations of ABS as low as 5 ppm in the filter influent cause head loss to increase at a greater rate than

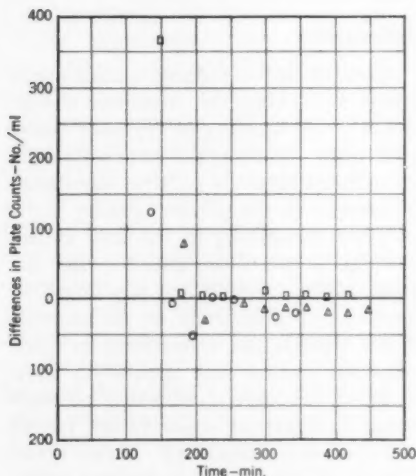


Fig. 7. Differences in Plate Counts of Filter Effluents

The values are determined by subtracting the plate count for control effluent from that for ABS effluent. Symbols indicate data from the following tests:  $\Delta$ —Run 19,  $\square$ —Run 20,  $\circ$ —Run 25.

ticles are of greater diameter than the upper limit of pseudo-colloid range (about  $10\mu$ ), as they most likely are, there is no valid reason for expecting that surface forces would influence the inertia and sedimentation forces (11).

The addition of ABS to the already coagulated and settled water made it possible to keep test and control filter influents identical, except for the sur-

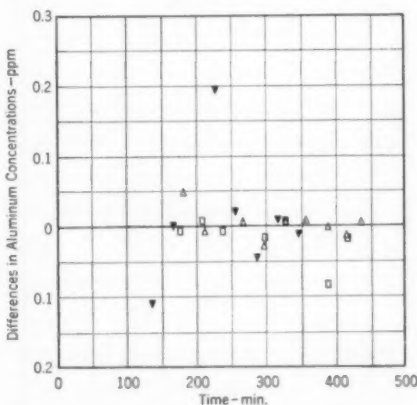


Fig. 8. Differences in Aluminum Concentrations Between Control and ABS Filter Effluents

The values are determined by subtracting the concentration for control effluent from that for ABS effluent. Symbols indicate data from the following tests:  $\Delta$ —Run 19,  $\square$ —Run 20,  $\blacktriangledown$ —Run 22.

normal. Runs with 5, 10, and 20 ppm fall well to the right of the 90-per cent confidence interval of the single run estimate (Line D in Fig. 9) while runs with 3 ppm did not. Theory suggests that 10 ppm of ABS would lower critical bubble size sufficiently to cause severe air binding. Comparison of Runs 20, 30, 25, and 26 rules out air binding as the cause of the increase rates of head loss actually observed. The ABS

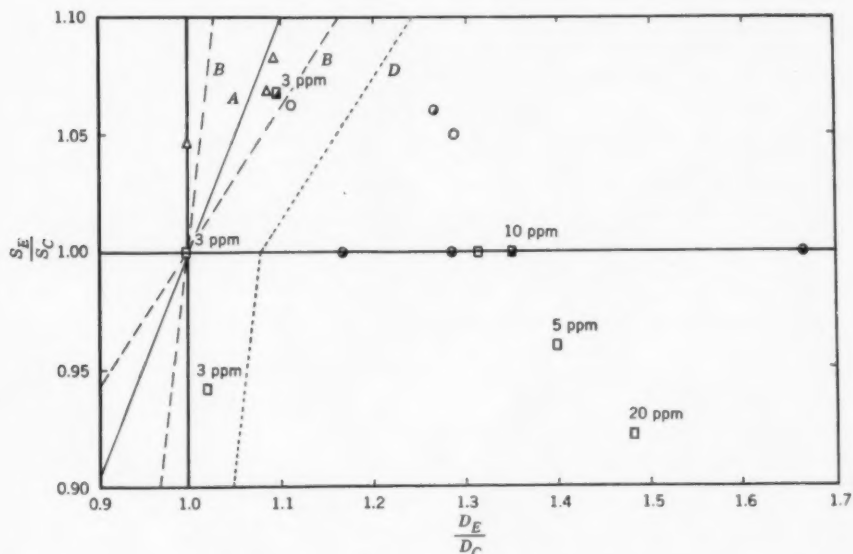


Fig. 9. Method of Correcting for Differences in Hydraulic Characteristics

Line A, the correction line, was plotted from the results of three control runs. The 90-per cent confidence intervals about A are bounded by Lines B. Line D represents the 90-per cent confidence limit (one sided) for any single run. The control run is indicated by  $\Delta$ ; runs using Quilon-coated sand by  $\circ$ ; and runs using ABS by  $\square$ . Partially shaded symbols indicate no deaeration.

apparently did not accumulate on the sand to produce anything approaching the Quilon-coated surface, or else air binding and increased rate of head loss would have occurred in Run 30 with supersaturated water.

We may rule out the differences in hydraulic properties of the filters and the level of oxygen saturation of the water as explanations of increased rates of head loss where ABS is added to the filter influent. The observed increases are probably due to some action of the sulfonate on the already formed floc. The ABS may or may not accumulate on the sand surfaces, but if it does, apparently it is not in such a way as to cause air binding as

does the Quilon coating in supersaturated waters.

It should be emphasized that a 5-ppm dose of ABS added to the filter influent is equivalent to the surfactant in 20-25 ppm of the common packaged household synthetic detergents.

### Conclusions

Based on the results presented, the following conclusions were drawn:

1. A filter sand, coated with stearate to simulate a hypothetical accumulation of surfactant, gives removals of bacteria and of aluminum as good as those obtained with clean uncoated filter sand.



2. Head losses increase at a greater rate in a stearate coated-sand filter than in a clean-sand filter, when the filter influent is supersaturated with respect to air. This is apparently due to a greater tendency to air binding in the presence of the stearate coating.

3. Adsorptive forces between the floc surfaces and the sand surfaces do not play a major role in the removal of floc by rapid sand filters.

4. Concentrations as high as 20 ppm of a polypropylene benzene sulfonate-type of surfactant, introduced into the coagulated and settled influents of clean-sand filters, do not reduce their efficiency for the removal of bacteria or of aluminum.

5. Concentrations of 5 ppm polypropylene benzene sulfonate, introduced into the coagulated and settled influents of clean-sand filters, cause head losses to increase at a significantly faster rate than in control filters. Increasing amounts of surfactant result in progressively greater effects; 3 ppm showed no effect.

6. The levels at which the alkyl benzene sulfonate component of synthetic detergents begins to show a direct adverse effect on the filtration process itself appear to be well above those being reported and those to be reasonably anticipated in water treatment practice.

7. The conclusions presented are based on data obtained under laboratory conditions. Their application to plant operating conditions remains to be established.

## Acknowledgment

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## Effects of Synthetic Detergents on Water Coagulation

—Russell S. Smith, Jesse M. Cohen and Graham Walton—

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**W**ITHIN the last 10 years, the synthetic detergents have secured a major portion of the detergent market. The increased sales have been mainly caused by an expansion of the market for the household type of synthetic detergents.

Coincident with the increased use of synthetic detergents have been various reports of water treatment difficulties ascribed to increased concentrations of these materials in streams. These reports, which are quoted in the comprehensive report of the AWWA task group on synthetic detergents (1), have indicated difficulties in coagulation as well as obnoxious tastes and odors of the finished water.

In general, the investigators quoted have been concerned with the surfactant component of the household detergent and have tended to ignore the other ingredients. Culp and Stoltenberg (2), however, suggested that the auxiliary ingredients may be fully as important to water plant operators as the surfactant, and stressed particularly that the phosphates may have an influence on colloidal behavior.

### Scope of Study

The present study was confined to the effect of household detergents on the alum coagulation of turbid waters and to a determination of the rate at which hydrolysis of the phosphate

component may occur in waste waters and streams. No tests were made on the effect of industrial-type detergents, which are usually compounded for specific usage and which generally contribute but a small portion of the detergent materials found in natural surface waters. Because alum is the coagulant most commonly used in water treatment, it was selected for use in this study.

Household-type detergents are mixtures of surface-active agents and other materials, such as impurities of manufacture or additives used for enhancing detergency or providing other desirable properties. The surfactant content of the detergent is 20-40 per cent of the finished product. The surfactant materials most commonly used are the alkyl aryl sulfonates—usually alkyl benzene sulfonates. Alkyl sulfates are sometimes incorporated, however. Both of these are anionic surfactants. The other major ingredients are sodium sulfate (comprising 10-60 per cent of the product) and polyphosphates (0-50 per cent). Although there is an increasing use of nonionics in household detergents, they have gained only a small portion of the market.

Because of the great variation in composition of the various household detergents, the tests reported were on the principal components rather than

on one of the commercially available detergents. Three companies dominate the household detergent market. They produce their alkyl aryl sulfonates by sulfonation of dodecyl benzenes purchased under their own specifications from a few petrochemical manufacturers. These petrochemical manufacturers also produce dodecyl benzene sulfonates for the commercial market, and samples of these were obtained from four of the petrochemical concerns to serve as the source for the alkyl benzene sulfonate surfactants used in the experimental work.

Although these four materials are all described by the suppliers as "essentially a dodecyl benzene sulfonate," or "predominantly dodecyl," there is no assurance that they are similar. Moreover, they are not pure chemicals but a series of homologs ranging from octyl benzene to hexadecyl benzene, with the predominant group being a dodecyl benzene.

Sodium lauryl sulfate (USP) was used to typify the alkyl sulfates used as surfactants. Commercial sodium triphosphate (commonly called tri-polyphosphate), tetrasodium pyrophosphate, and trisodium phosphate (orthophosphate) were considered representative of the phosphates that might be found in streams as a result of detergent pollution. Ground filter alum obtained from the Cincinnati water treatment plant was used as the coagulant. This material assayed 17.0 per cent  $Al_2O_3$  and 13.5 moles of water of hydration.

## Methods

To eliminate the variables occurring in natural waters, a turbid water was prepared in the laboratory. A local

clay was suspended in distilled water, the suspension allowed to settle, and the supernatant was siphoned off for a "stock turbidity." Distribution of particle sizes was determined microscopically for four stock turbidities. Particles less than  $1\mu$  in size were disregarded. The results showed that 85 per cent of the particles were  $1-3\mu$ , 11 per cent were  $3-5\mu$ , and 4 per cent were over  $5\mu$  in size. To make a "synthetic soft turbid water" having 100 ppm turbidity and 50 ppm alkalinity for the coagulation experiments, this stock turbidity was used with sodium bicarbonate and distilled water. For certain experiments, calcium chloride was added to provide calcium hardness up to 200 ppm, as calcium carbonate. The synthetic turbid water (or raw water) was quite uniform in characteristics. Results from 89 samples showed turbidities of 81-126 ppm, with 70 per cent of the values between 95 and 105 ppm. Alkalinities of 48-55 ppm were noted, with 80 per cent between 51 and 53 ppm.

Concentrations of surfactant were determined by the two-phase titration method proposed by Hoyt and Walter (3). The cetyl trimethyl ammonium bromide (CETAB) solution used for the titration was standardized against potassium dichromate. All calculations were based on a molecular weight of 348—the weight of a dodecyl benzene sulfonate.

Orthophosphate and soluble polyphosphate were determined by the colorimetric molybdenum blue method, using stannous chloride as reducing agent and measuring color intensity with a spectrophotometer. This method is given in *Standard Methods* (4).

All turbidity measurements were made with a spectrophotometer at a wave length of 470  $m\mu$ , using a 5-cm cell after calibration against a Jackson candle turbidimeter.

Because the materials supplied by the various surfactant manufacturers were commercial products contaminated with varying amounts of inorganic salts, all surfactants were subjected to a purification procedure. This consisted of separating the inorganic material from the organic surfactant by alcohol extraction. The purity of the material was determined by titration with standard cetyl trimethyl ammonium bromide, according to the procedure previously described. Final purity of the materials was 90-97 per cent.

All experiments on coagulation and settling were made with six-place laboratory stirrers using wide-mouth, square-sided, gallon jars. Two liters of raw water were put into each jar. The desired amounts of detergent component (surfactant or phosphate) were added from a standardized solution and the mixture was stirred vigorously. All alum dosages were based on weight of the commercial filter alum used. The alum coagulant solution was measured into small beakers to facilitate rapid transference to the jars. Although 6 ppm of alum was generally sufficient to coagulate this water, a minimal dosage of 10 ppm was used in most experiments. The coagulation period was 30 min, with the paddles turning at 42 rpm to provide a paddle tip velocity of 43 ft per minute. Time of first floc formation was noted and visual observations of floc quality were made during the coagulation period. After coagulation, the contents of the jars were allowed

to settle for 60 min, during which time observations of settling quality of the floc were made. At the end of the settling period, effluent samples were siphoned from approximately 1 in. below the surface for turbidity and chemical determinations.

### Experimental Results

The four dodecyl benzene sulfonates used are designated ABS-1, -2, -3, and -4 for reference purposes. Varying amounts of the surfactant under test were added to the jars of soft raw water at room temperature, and coagulation tests were made using 10 ppm alum as coagulant. Similar tests were made using sodium lauryl sulfate. The results of the several tests made on each of the dodecyl benzene sulfonates and on sodium lauryl sulfate are given in Table 1.

Results obtained with ABS-1 were erratic. In two tests, interference with coagulation and clarification was caused by a concentration of 8 ppm. This concentration is at least twice the maximum concentration reported in a natural water. In one test, there was interference from a concentration of 12 ppm and in another from concentration of 16 ppm. In still another test, however, 16 ppm did not cause interference. The other three alkyl benzene sulfonates showed no evidence of interference with the coagulation of this turbid water at concentrations of 16 ppm.

Infrared curves of surfactant materials, extracted from various natural waters and sewages, indicate that these surfactants are nearly identical with ABS-2. An infrared curve of ABS-1 shows that it is quite different structurally from the other alkyl benzene sulfonates used in this study. Infor-

TABLE 1  
Coagulation Tests on Surfactants in Soft Turbid Water

Item	Surfactant Concentration—ppm						Surfactant Interference Concentration*—ppm
	0	2	4	8	12	16	
ABS-1							
First floc—min	10	10	10	10			
Floc quality	good	good	good	fine		none	8
Effluent turbidity—ppm	2	4	6	15		62	
First floc—min							
Floc quality	good		good	good	pin point	none	8
Effluent turbidity—ppm	5		8	18	43	77	
First floc—min	6	6	6	6	6	6	
Floc quality	good	good	good	good	good	good	>16
Effluent turbidity—ppm	1	2	1	2	2	2	
First floc—min	10	10	10	11	18		
Floc quality	good	good	good	good	fine	none	12
Effluent turbidity—ppm	5	4	4	6	17	64	
First floc—min	7	7	7	7	10		
Floc quality	good	good	good	good	good	none	16
Effluent turbidity—ppm	3	3	3	3	8	60	
ABS-2							
First floc—min							
Floc quality	good	good	good	good		good	>16
Effluent turbidity—ppm	6	4	4	4		3	
First floc—min	7	7	7	7	7	8	
Floc quality	good	good	good	good	good	good	>16
Effluent turbidity—ppm	2	2	2	2	3	2	
ABS-3							
First floc—min	6	6	6	6	6	6	
Floc quality	good	good	good	good	good	good	>16
Effluent turbidity—ppm	2	3	3	2	3	2	
First floc—min	8	8	9	9	9	10	
Floc quality	good	good	good	good	good	good	>16
Effluent turbidity—ppm	3	3	3	3	3	3	
ABS-4							
First floc—min	7	7	7	8	8	8	
Floc quality	good	good	good	good	good	good	>16
Effluent turbidity—ppm	3	3	3	3	3	3	
First floc—min	7	7	7	7	8	9	
Floc quality	good	good	good	good	good	good	>16
Effluent turbidity—ppm	4	4	4	3	4	4	
Lauryl Sulfate							
First floc—min	6		6	9	15		
Floc quality	good		good	good	fine	none	12
Effluent turbidity—ppm	4		4	6	17	90	
First floc—min	7		7	7	7	9	
Floc quality	good		good	good	good	good	>16
Effluent turbidity—ppm	1		1	2	2	3	
First floc—min	8		8	8	8	9	
Floc quality	good		good	good	good	good	>16
Effluent turbidity—ppm	2		2	2	3	4	

\* Concentration of surfactant at which interference with coagulation and clarification occurred.

TABLE 2  
Coagulation Tests on Surfactants in Warm and Cold Soft Turbid Water

Item	Raw Water Temperature* °C	Surfactant Concentration—ppm							Surfactant Interference Concentration†—ppm
		0	2	4	8	12	16	20	
ABS-2									
First floc—min	28½	7	7	7	7	7	8		> 16
Floc quality		good	good	good	good	good	good		
Effluent turbidity—ppm		2	2	2	2	3	2		
First floc—min	7	9		10	10	11	12	12	> 20
Floc quality		good		good	good	good	good	fine	
Effluent turbidity—ppm		2		3	3	3	3	3	
Lauryl Sulfate									
First floc—min	28	8		8	8	8	9	13	20
Floc quality		good		good	good	good	good	good	
Effluent turbidity—ppm		2		2	2	3	4	11	
First floc—min	9	10		10	10	10	11	11	> 20
Floc quality		good		good	good	good	good	fine	
Effluent turbidity—ppm		2		3	3	2	2	2	

\* Temperature rise of cold water during coagulation and settling was 5° or 6°C.

† Concentration of surfactant at which interference with coagulation and clarification occurred.

mation obtained from a detergent manufacturer indicates that ABS-1 is not used as a surfactant in the major household synthetic detergents.

The lauryl sulfate interfered with coagulation at a concentration of 12 ppm in one experiment, but in two other tests there was no interference from 16 ppm.

Two coagulation experiments were made to determine the effect of surfactants in cold water. The results of these experiments are given in Table 2 and show that, within the range studied, the temperature of the raw water had no influence on the effect of the surfactant.

Two tests were made with ABS-2 to determine the effect of surfactants on the coagulation of hard waters. In

one of these experiments calcium chloride was added to the soft synthetic raw water to provide 100 ppm calcium hardness. The other water was from a local stream that is relatively free from pollution. The minimum amounts of alum that would provide adequate coagulation and clarification for these waters were used in these experiments. It was thought that by the use of this smaller amount of coagulant, any possible coagulation interference of the surfactant would be readily apparent. The results are tabulated in Table 3. No interference with coagulation was caused by the surfactant at concentrations as high as 25 ppm.

Although it was considered improbable that there would be coagulation



interference from the sodium sulfate which usually accompanies these surfactants, an experiment to test the hypothesis was considered essential. A single experiment was made using 4 ppm of ABS-2, 10 ppm alum for coagulant, and 0-64 ppm of sodium sulfate. No interference with the coagulation of the synthetic raw water was observed.

Sodium tripolyphosphate is used in various concentrations in nearly all

thetic raw water, using 10 and 20 ppm of alum as coagulant. The results obtained are shown in Table 4.

Both the tripolyphosphate and the pyrophosphate completely inhibited coagulation at very low concentrations, but the critical concentration could be increased by a substantial increase in the alum dosage.

A series of experiments was made to determine the interrelated effects of phosphate concentration and alum

TABLE 3  
*Dodecyl Benzene Sulfonate Surfactant (ABS-2) in Hard Water*

Item	Surfactant Concentration— <i>ppm</i>						Surfactant Interference Concentration <sup>2</sup> — <i>ppm</i>
	0	5	10	15	20	25	
Synthetic Raw Water†							
First floc— <i>min</i>	12	12	12	12	12	12	> 25
Floc quality	fine	fine	fine	fine	fine	fine	
Effluent turbidity— <i>ppm</i>	5	5	5	6	6	6	
Water from Local Stream‡							
First floc— <i>min</i>	7				6	6	> 25
Floc quality	good				good	good	
Effluent turbidity— <i>ppm</i>	4				4	4	

\* Concentration of surfactant at which interference with coagulation and clarification occurred.

† Characteristics of the synthetic raw water were: hardness, 100 ppm; alkalinity, 50 ppm; turbidity, 95 ppm. In this test, 6 ppm alum was used.

‡ Characteristics of the natural water were: hardness, 218 ppm; alkalinity, 183 ppm; turbidity, 40 ppm; and pH of 7.9. In this test, 7 ppm alum was used.

of the major brands of household detergents. The hydrolysis of one molecule of tripolyphosphate yields one molecule each of pyrophosphate and orthophosphate. The molecule of pyrophosphate then hydrolyzes to two molecules of orthophosphate. For this reason, the effects on coagulation of all three forms of phosphate were studied.

Coagulation experiments were made with the various phosphates in syn-

dosage on coagulation of soft synthetic raw water. A rapidly settling floc and an effluent turbidity of 5 ppm or less were considered to indicate satisfactory coagulation and clarification. The results obtained with the complex phosphates agree closely with those reported by Langelier et al. (5), who studied the effect of sodium hexametaphosphate on alum flocculation of water containing 0.5 milliequivalents of alkalinity per liter and 60 ppm tur-

bidity. The results obtained are shown in Fig. 1, where the amount of alum necessary for satisfactory coagulation and clarification is plotted against concentration of commercial phosphate. Some of the tests on the complex phosphates were made with alum dosage increments of 5 ppm and some with increments of 2 ppm, which

Tests were made with different concentrations of polyphosphate in cold synthetic raw water ( $7^{\circ}$ – $10^{\circ}$ C). These results are included in the results plotted in Fig. 1. It is generally more difficult to obtain coagulation in cold than in warm water. It was surprising, therefore, to find that, for a given concentration of polyphosphate,

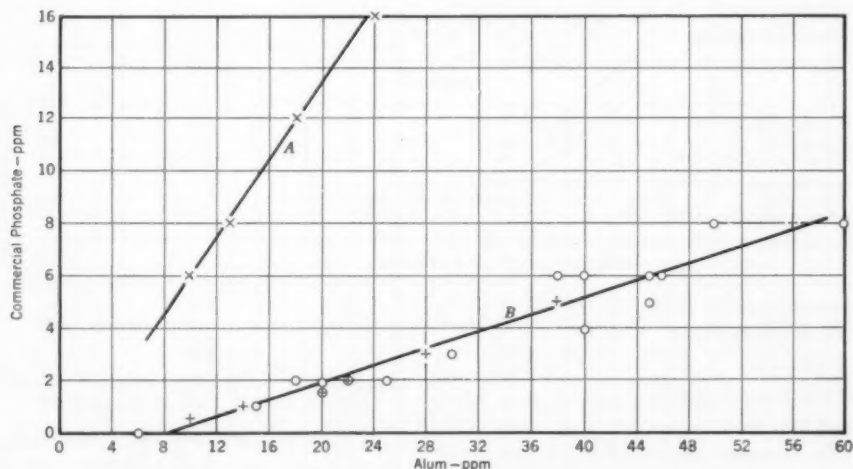


Fig. 1. Effect of Phosphates on Alum Coagulation of Soft Synthetic Turbid Water

Points plotted represent data from tests on the following:  $\circ$ —sodium triphosphate;  $+$ —tetrasodium pyrophosphate;  $\times$ —trisodium phosphate. Line A is the curve for orthophosphate, line B for polyphosphate. The amounts of alum plotted are the amounts necessary to produce a turbidity of 5 ppm or less.

probably accounts for some of the scattering of the plotted points. The experiments on orthophosphate effect were made with 2-ppm alum increments and the results are more consistent. The tripolyphosphates and pyrophosphates are similar in their effects on alum coagulation. The concentration of orthophosphate at which interference occurs is much higher.

less alum was required for coagulations in cold than in warm water.

Figure 2 illustrates how closely comparable are the effects of the tripolyphosphate and the pyrophosphate on alum coagulation. In these two experiments, 2 ppm of phosphate compound was added to the raw water and alum dosages were increased by steps of 1 ppm. The effluent turbidity—

TABLE 4  
Coagulation Tests on Phosphates in Soft Turbid Water

Item	Alum Used <i>ppm</i>	Phosphate Concentration— <i>ppm</i>										Phosphate Interference Concentration*— <i>ppm</i>	
		0	0.5	1.0	1.5	2.0	3.0	4.0	6.0	8.0	12.0		16.0
Tripolyphosphate													
First floc— <i>min</i> Floc quality Effluent turbidity— <i>ppm</i>	10	7 good 5	8 fine 15	none 78	none 76	none 76							0.5
First floc— <i>min</i> Floc quality Effluent turbidity— <i>ppm</i>	20	5 good 1		5 good 1	5 good 1	none 95							2.0
Pyrophosphate													
First floc— <i>min</i> Floc quality Effluent turbidity— <i>ppm</i>	10	7 fine 3	7 fine 3	none 82		none 84							1.0
First floc— <i>min</i> Floc quality Effluent turbidity— <i>ppm</i>	20	8 good 2		6 good 1	6 good 1	10+ fine 19	none 76						2.0
Orthophosphate													
First floc— <i>min</i> Floc quality Effluent turbidity— <i>ppm</i>	10	7 good 2	7 good 2	7 good 2	7 good 1	7 good 2		7 good 4					>4.0
First floc— <i>min</i> Floc quality Effluent turbidity— <i>ppm</i>	10	9 good 3						9 good 4	10 good 15	18 fine 40	none 80	none 79	6.0
First floc— <i>min</i> Floc quality Effluent turbidity— <i>ppm</i>	20	7 good 2						6 good <1	6 good <1	6 good 1	6 good 4	7 light 23	16.0

\* Concentration of surfactant at which interference with coagulation and clarification occurred.

alum dosage curves for the two phosphate compounds are nearly identical. It was noted that when sufficient alum was used to overcome the phosphate interference, the resultant floc was somewhat larger than that formed in the absence of phosphate.

It was considered possible that if the polyphosphates were present in waters with considerable calcium hardness, the calcium would react with the phosphates to form complex calcium phosphates and thus overcome the phosphate interference. To determine the amount of alum needed to

produce an effluent with 5 ppm or less turbidity, a series of coagulation experiments was made using various concentrations of polyphosphate in synthetic raw waters with calcium hardness ranging from 0 to 200 ppm. The results are shown in Fig. 3. Although satisfactory clarification was obtained with much lower alum dosages than would have been necessary for the corresponding phosphate concentrations in soft water, the floc formed much more slowly, and was very light and slow settling. These tests were conducted under laboratory

conditions with 60-min, quiescent settling in relatively shallow jars. It is questionable whether the floc would have been removed in the settling tank of an operating plant. Although satisfactory clarification was obtained, the flocculation was decidedly unsatisfactory. Increased alum dosage beyond the required minimum yielded an effluent with lower turbidity, although the floc was still very fine and slow settling.

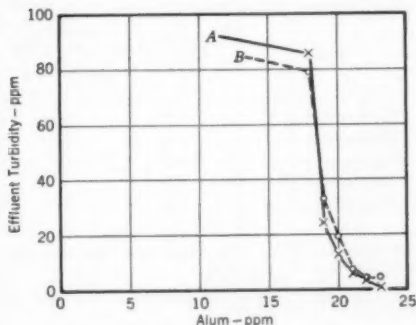


Fig. 2. Comparison of Effects of Complex Phosphates in Soft Turbid Water

Data from tests on raw water containing 2 ppm pyrophosphate are indicated by points  $\times$  and line A. Data from tests containing 2 ppm tripolyphosphate are indicated by points  $\circ$  and line B. The effects of the two phosphates are seen to agree closely.

Coagulation of natural hard water in the presence of tripolyphosphate was attempted by increasing the alum dosage from the minimal of 6 or 7 ppm to 10 ppm and higher. Satisfactory clarification was obtained with 10 ppm alum when phosphate concentrations were as high as 8 ppm. In the presence of 2 ppm or more of tripolyphosphate, however, the floc was fine and rather slow settling. Increasing alum dosages to as high as 50 ppm did not improve floc quality appreciably.

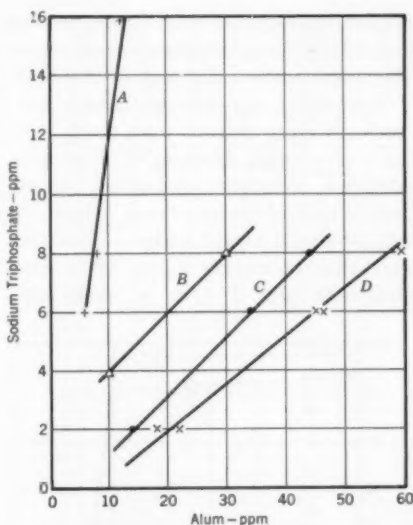


Fig. 3. Effect of Sodium Triphosphate in Hard Synthetic Raw Waters

Line A was plotted from data (+) for water with 200 ppm hardness; line B from data ( $\Delta$ ) for water with 100 ppm hardness; line C from data ( $\bullet$ ) for water with 50 ppm hardness; and line D from data ( $\times$ ) for water with 0 ppm hardness. The amounts of alum are the amounts necessary to produce effluent turbidity of 5 ppm or less.

### Household Synthetic Detergents

As a check on the experimental work with detergent components in soft synthetic turbid water, four common household detergents were purchased at a retail grocery. One of these detergents contained no polyphosphate, one had about 25 per cent polyphosphate, and the other two had approximately 50 per cent. For each detergent, that concentration was determined which caused no apparent flocculation in synthetic soft turbid water when 10 ppm of alum were used as coagulant. The concentrations of these synthetic detergents which

caused interference was equivalent to that of the phosphate component alone. The results are tabulated in Table 5.

Two other experiments which corroborate these results were made. In one experiment, 16 ppm of a popular household detergent containing 50 per cent tripolyphosphate was added to soft synthetic turbid water. This was equivalent to adding 8 ppm of tripolyphosphate and 3 ppm of surfactant.

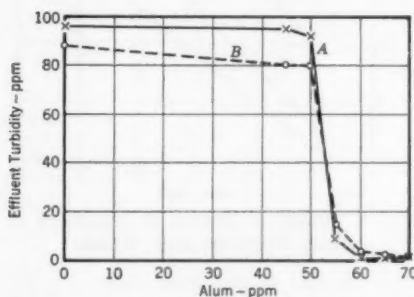


Fig. 4. Comparison of Household Detergent and Tripolyphosphate in Soft Turbid Water

Line A was plotted from data (X) for water containing 16 ppm household detergent (equivalent to 3 ppm surfactant and 8 ppm tripolyphosphate). Line B was plotted from data (O) for water containing 8 ppm commercial tripolyphosphate.

Alum, in amounts varying from 45 to 70 ppm, was used as coagulant. In the other experiment, 8 ppm of commercial tripolyphosphate was added under the same conditions. The results are shown in Fig. 4, where alum dosages are plotted against resulting effluent turbidities.

These experiments with household synthetic detergents show that interference with alum coagulation is due to the polyphosphate content rather than to the surfactant.

## Polyphosphate Reversion

When anhydrous orthophosphates containing hydrogen are heated to specific temperatures, definite amounts of water are removed, causing one or more phosphate units to join. These phosphates, in which two phosphorous atoms are linked through an oxygen

TABLE 5

Interference Caused by Household Synthetic Detergents\*

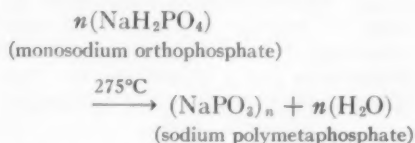
Item	Interference Conc.† ppm	Resulting Polyphosphate Concentration‡ ppm
Detergent A	2	1
Detergent B	4	1
Detergent C	>16	0
Detergent D	1	1
Polyphosphate	1	1

\* Tests were made in synthetic raw water and the coagulant was 10 ppm alum.

† No apparent flocculation.

‡ Based on polyphosphate content of detergent as reported by manufacturer.

atom, are called polyphosphates, or molecularly dehydrated phosphates. This dehydration is as follows:



where  $n$  represents the number of molecules of monobasic orthophosphate reacted and the number of units of polymetaphosphate produced.

The polyphosphates studied were tetrasodium pyrophosphate, which is produced by dehydrating two molecules of disodium orthophosphate ( $\text{Na}_2\text{HPO}_4$ ), and sodium triphosphate (sodium tripolyphosphate), which is derived from two molecules of disodium and one molecule of monosodium orthophosphates ( $\text{NaH}_2\text{PO}_4$ ).

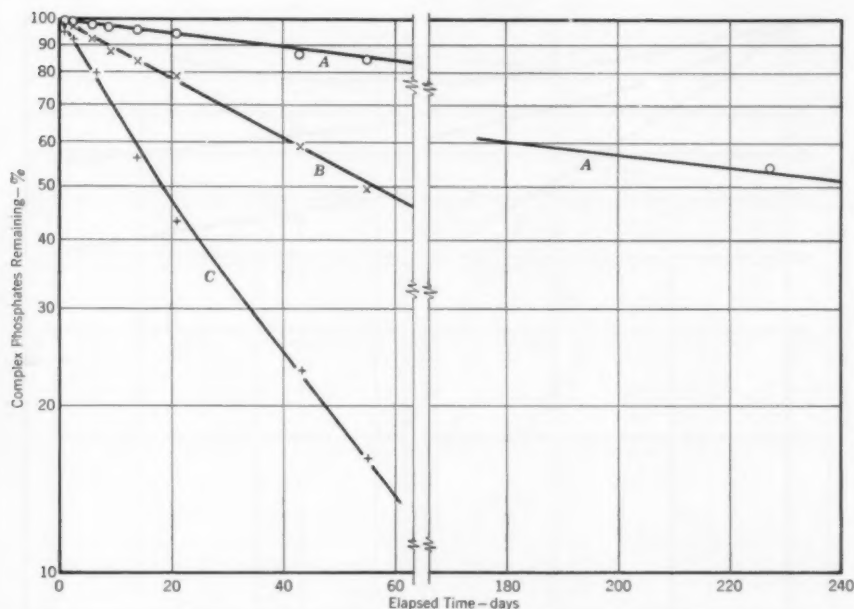
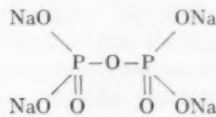


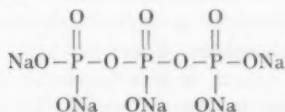
Fig. 5. Tripolyphosphate Reversion in Ohio River Water

Data from tests on water at 5°C with half life of 240 days are indicated by points  $\circ$  and line A. Data for water at 20°C with half life of 55 days are indicated by points  $\times$  and line B. Data for water at 35°C with half life of 18 days are indicated by points  $+$  and line C. Other characteristics of the water were: turbidity, 248 ppm; pH, 7.5; alkalinity, 23 ppm (as  $\text{CaCO}_3$ ). The hardness was 64 ppm (as  $\text{CaCO}_3$ ), of which 44 ppm (as  $\text{CaCO}_3$ ) was calcium and 20 ppm (as  $\text{CaCO}_3$ ) was magnesium.

The structural formulas for tetra-sodium pyrophosphate ( $\text{Na}_4\text{P}_2\text{O}_7$ ) may be illustrated as follows:



The formula for sodium triphosphate ( $\text{Na}_5\text{P}_3\text{O}_{10}$ ) is:

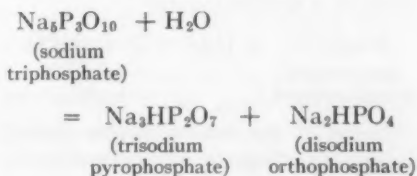


In the synthetic-detergent field, these two make up the bulk of the

phosphates used, with the triphosphate being more commonly used.

### Hydrolytic Behavior

In aqueous solution the molecular dehydrated phosphates take up water to reform orthophosphates. The hydrolysis of sodium triphosphate proceeds in two steps:





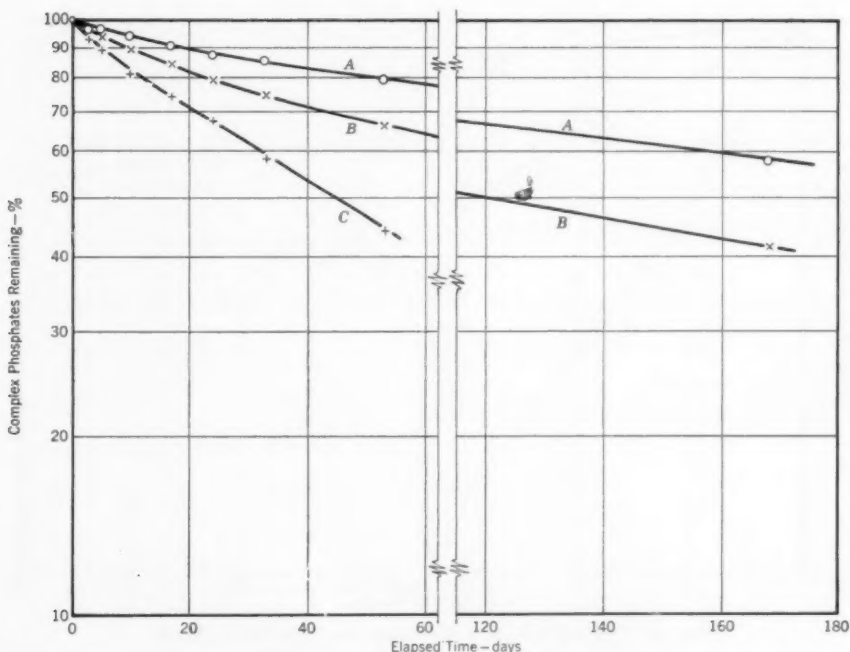
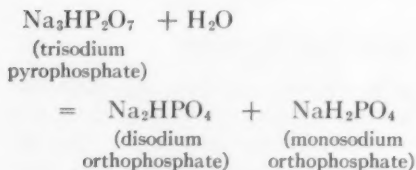
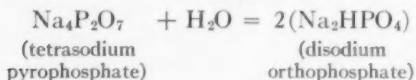


Fig. 6. Pyrophosphate Reversion in Ohio River Water

Data from tests on water at 5°C with half life of 220 days are indicated by points ○ and line A. Data for water at 20°C with half life of 120 days are indicated by points × and line B. Data for water at 35°C with half life of 45 days are indicated by points + and line C. Water characteristics were: turbidity, 77 ppm; pH, 7.5; alkalinity, 36 ppm (as CaCO<sub>3</sub>). The hardness was 121 ppm (as CaCO<sub>3</sub>), of which 84 ppm (as CaCO<sub>3</sub>) was calcium and 37 ppm (as CaCO<sub>3</sub>) was magnesium.



Tetrasodium pyrophosphate hydrolyzes in a similar manner:



Some of the known environmental factors affecting the rate of hydrolysis

or reversion are enzymes, gels of inorganic oxides, pH, temperature, complexing agents (such as calcium, magnesium, or sodium), and concentration of the phosphate (6).

Because it has been shown that polyphosphates interfere with coagulation of turbid waters, and that the hydrolysis product of polyphosphates, namely orthophosphate, interferes to a much lesser extent, it was important to determine the rate at which this reversion might occur. A convenient term to use in the reversion of polyphos-

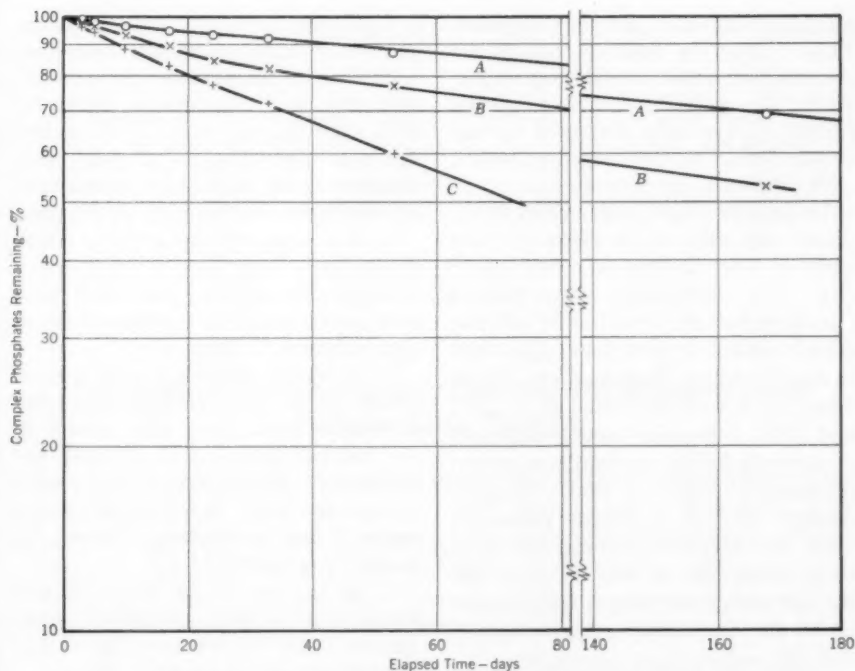


Fig. 7. Pyrophosphate Reversion in Local Stream Water

Data for water at 5°C with half life of 310 days are indicated by points  $\circ$  and line A. Data for water at 20°C with half life of 180 days are indicated by points  $\times$  and line B. Data for water at 35°C with half life of 75 days are indicated by points  $+$  and line C. Water characteristics were: turbidity, 31 ppm; pH, 8.1; alkalinity, 195 ppm (as  $\text{CaCO}_3$ ). The hardness was 223 ppm (as  $\text{CaCO}_3$ ), of which 162 ppm (as  $\text{CaCO}_3$ ) was calcium and 61 ppm (as  $\text{CaCO}_3$ ) was magnesium.

phates is "half life," which indicates the time required for 50 per cent of the original polyphosphate to be hydrolyzed to orthophosphate.

In order to determine the amount of reversion of the polyphosphates that might occur during normal laundering in a household using a synthetic detergent containing polyphosphates, a single experiment was made.

A washing solution containing 0.3 per cent of a popular household synthetic detergent, known to contain a

high percentage of sodium triphosphate, was heated to 150°F and maintained at that temperature for 1 hr. The orthophosphate was determined both before and after the heating period. The tap water used for the solution had a pH value of 8.2 and a hardness of 90 ppm. The detergent solution had a pH value of 9.2 and no apparent hardness by the EDTA titration method. This single experiment showed no demonstrable increase in orthophosphate and, therefore, no sig-

nificant reversion of the polyphosphate. Thus, it may be inferred that, under normal household laundering procedure, the polyphosphates originally present in synthetic detergent formulations would be discharged to waste, with practically no reversion.

In another experiment, Ohio River water was allowed to settle for one hour in order to remove coarse particles. The supernatant was dispensed into three bottles, to each of which was added sodium triphosphate equivalent to approximately 20 ppm of phosphate. The bottles were incubated at 5°, 20°, and 35°C. Samples were withdrawn at intervals for determination of orthophosphate. Figure 5 shows the percentage of polyphosphate remaining after the indicated number of days. From these data it may be seen that the half life of the sodium triphosphate at 5°, 20°, and 35°C is approximately 240, 60, and 20 days, respectively.

This test was repeated with Ohio River water at the same temperatures, but using tetrasodium pyrophosphate. The results are presented in Fig. 6, which shows that the half life at 5°, 20°, and 35°C is approximately 220, 120, and 45 days, respectively.

A third test using a harder water obtained from a local stream was made with tetrasodium pyrophosphate with results as shown in Fig. 7. The half life at 5°, 20°, and 35°C was approximately 310, 180, and 75 days.

## Conclusions

The results of foregoing experimental work led to the following conclusions:

1. Household-type synthetic detergents may cause coagulation difficulties.

2. Two of the surface active agents used in these experiments interfered with alum floc formation in the waters tested at concentrations of 8-20 ppm. Another agent showed no interference at concentrations as high as 25 ppm.

3. The complex phosphates, which constitute a large proportion of many synthetic detergents, interfered with alum coagulation at concentrations of approximately 1 ppm.

4. Reversion of these complex phosphates to the less troublesome orthophosphate took place very slowly in the natural waters used in these experiments. The effects of the complex phosphates may therefore be noted many miles downstream from the source of pollution.

5. In the soft water tested, it was found that complex phosphate interference could be overcome by a substantial increase in the alum dosage.

6. In the hard water tested, alum floc which formed in the presence of complex phosphates was fine and settled slowly. It is probable that in a water treatment plant much of this floc would have been carried on to the filters.

7. At water treatment plants where synthetic-detergent pollution may cause coagulation difficulties, determination of soluble polyphosphate concentrations as well as surfactant concentrations should be made.

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### Revision of Standards for Threads for Underground Service Line Fittings

In accordance with the recommendation of the Water Works Practice Committee, approved by the Board Jan. 17, 1955, that "in the next revision of the Standard Specifications for Threads for Underground Service Line Fittings (C800), the requirement be written in that the composition of the metal of the castings be on the industry-accepted basis of 85-5-5-5 percentage copper, lead, tin, zinc," the following paragraph is being added to Sec. 1-1:

1.2. Unless otherwise specifically directed by the purchaser, the service line fittings shall be of "ounce metal," containing 85 per cent copper and 5 per cent each of tin, lead, and zinc (ASTM B62).

The designation of the specification will now be C800-55.

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## Soap Manufacturers' Report of Research on Synthetic Detergents

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F. J. Coughlin

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*A paper presented on Apr. 14, 1955, at the Kansas Section Meeting, Hutchinson, Kan., by F. J. Coughlin, Chairman, Technical Advisory Subcommittee on Research, Assn. of American Soap and Glycerine Producers, New York, N.Y.; Chem. Engr., The Procter and Gamble Co., Ivorydale, Ohio.*

THE research program discussed here was organized by the Association of American Soap and Glycerine Producers to offer assistance in the solution of sewage treatment and water quality problems resulting from synthetic-detergent pollution. The investigations which the association has made to date involve the development of improved methods of analysis for the trace quantities of alkyl benzene sulfonate (ABS) which might be found in raw surface waters or in sewage effluents. The investigation began with ABS because, from the point of view of volume used, it is the most important of the surface-active agents present in the synthetic detergents on the market.

By way of clarification, the phrase "synthetic detergent" is used in this discussion to refer to complete products as they are found in the package. They may contain surface-active agents such as ABS and inorganic and organic builders. Use of synthetic detergents has grown to a point where they comprise well over half of all the household washing products used.

### Need for Research

The analytical problem involved is an extremely interesting one. It appears that the procedure for analyzing ABS now in the process of develop-

ment will be very useful in basic studies.

The association realizes, however, that as yet it has not developed a method which will be practical for routine use by the average operator. The search for such a method still remains an important part of the association's work.

In giving top priority to the analytical problem, the soap industry is following the suggestions of the Ohio River Valley Water Sanitation Commission (ORSANCO) which, a little more than a year ago, created a subcommittee on detergents as part of its Chemical Industry Advisory Committee. The problem of developing better methods of analysis for synthetic detergents is also first on the list of items recommended for further study in the report of the AWWA task group on detergents (1). The U.S. Public Health Service has also recognized the problem, and reported on a new colorimetric analytical method at the American Chemical Society meeting held in Cincinnati on April 4, 1955. This method, using methyl green as the indicator, shows promise of not being affected by some of the interferences which are encountered in the standard methylene blue procedure. Also, it is a simpler and possibly more reliable method, even when no inter-

ferences are present. The interest of ORSANCO, AWWA, and the Public Health Service points up the fact that past analytical procedures have not performed the kind of job that is needed for a precise and careful study of the problem.

### Surfactant Behavior

Surface-active agents reduce surface tension at the water-air boundary and, by concentrating in the surface of the water, operate to form a suds or froth. There are, however, many substances of varying chemical composition which behave in this manner. Also, when enough surfactant is present, a solution will tend to suspend any dirt in the form of fine solid particles.

Every solids particle requires a great many molecules of surfactant to surround it and keep it from agglomerating with other particles and settling out. To obtain the proper suds in a dishpan, for instance, a housewife uses about 3,000 ppm of the packaged detergent, or about 600 ppm of ABS. The detergent molecules are effectively taken out of action by the soil particles, thus explaining the loss of suds in the dishpan after continued washing of dishes. Considering these two factors and others reported by W. R. Gowdy, it would seem that "the extremely dilute concentrations of synthetics found in sewage can hardly alone be capable of causing frothing or settling problems (2)."

### Analytical Procedure

Natural surface-active agents present in the living state, and others, are produced from the decomposition of various types of organic matter. The task group report (1) says that the natural production of such surface-active agents is considerable, and fur-

ther states that "the existence of these natural surfactants can be demonstrated by soaking grass, straw, or leaves in water. The extracts foam and there is substantial lowering of the surface tension of the water. Raw waters may be expected to contain varying amounts of natural surfactants." These reasons account for the problems of finding a method to give a precise quantitative determination of the amount of synthetic detergent present in raw waters, sewage, or sewage effluent. Some of the natural surface-active agents and some organic substances, which may not even be surface active, also interfere with the ordinary methods of analysis for ABS. The interference is such, for example, that, in analyzing a sample of distilled water known to contain no ABS but to which some interference is added, ordinary analytical methods erroneously show significant amounts of ABS to be present.

The problem of interferences in all types of organic analyses is, of course, one of the occupational hazards of the analytical chemist. Almost without exception, when a new method of analysis is developed for an organic material, interference becomes a problem. The difficulty with interferences is obviously greatest at the low-concentrations of ABS which need evaluation. In raw water, for example, these concentrations are rarely as high as a few parts per million.

Ordinary methods, incidentally, are still suitable in those situations where the concentrations are so low that they are insignificant. This is true because ordinary methods give a maximum possible result. The Ohio River, for example, with a good flow in the latter part of March, showed less than 0.1 ppm of "apparent ABS" by the methylene blue procedure. Even if the



entire amount of apparent ABS should be real ABS, there is no need for checking the river water by more laborious and time-consuming methods. When the amounts shown to be present by the methylene blue or other ordinary methods begin to be appreciable, however, a new method is needed to determine whether ABS is actually present. A method such as this can be useful as a basic tool in further research for the solution of the problems involved.

During the past few years, quite a number of different analytical procedures for determining ABS have been developed, all of which seem to have "interference trouble." Analysis of one sample of urine, for instance, gave 22 ppm of apparent ABS by the methylene blue method. Biologically, it is reasonable to assume that human beings do not produce any ABS in their systems. Also, a particular sample of an extract of straw, analyzed 0.7 to 0.9 ppm apparent ABS, by both the methylene blue and the methyl green methods. The interferences persisted when known amounts of ABS were added to this sample of straw extract.

Cationic titration methods are suitable for analyzing high concentrations, but their sensitivity is questionable on samples that contain less than 10 ppm of ABS. Depending on the type, condition, and other characteristics of the sample, there are serious questions about these methods in the range 10-100 ppm ABS.

A frequent practice for reporting total synthetic detergent has been to determine the ABS and, by means of a standard, convert to the basis of finished-package synthetic-detergent product. The amount of synthetic detergent is about four to five times the amount of ABS found. Naturally,

any error in the primary analysis of ABS is amplified by this method.

### Use of Infrared

The Soap Association technical group, which has studied the analytical methods, looked for a new approach which would yield the unequivocal qualitative and quantitative results needed. Characterization by means of an infrared spectrophotometer would be one answer, but only if complete separation and removal of the ABS could be accomplished.

The absorption of wave lengths of ultraviolet, visible, or infrared radiation is a method used for fingerprinting any chemical compound. The compound will absorb some of the wave lengths to which it is exposed and will allow others to pass through it. For ABS, as mentioned, the infrared wave lengths are used. By making a graph or curve showing how much of each wave length is absorbed, the fingerprint, or "absorption spectrum," can be obtained. The equipment used in obtaining this absorption spectrum is the infrared spectrophotometer—a different instrument from the colorimeter, sometimes referred to as a spectrophotometer, which is used in the measurement of color. Spectrophotometers may be set up with devices which quickly give a graphic record of the fingerprint.

The shape of the absorption spectrum is useful for positive qualitative analysis and the amount of absorption at a particular wave length allows accurate quantitative analysis. To run an infrared characterization of ABS in low concentrations, it is necessary to concentrate the trace amounts present. For a quantitative procedure, the ABS would have to be completely removed from the sample being analyzed.

The tendency of surface-active molecules to adsorb on solids offered a possibility of accomplishing the desired result. Research at the Taft Engineering Center in Cincinnati had used activated carbon in collecting and concentrating the trace amounts of organic matter from Ohio River water. Activated carbon was therefore considered for study in connection with the association's research. Alumina is another solid which has high adsorptive power and it, too, was used in preliminary studies. The technique was to pass a known measured quantity of water through a column of the solid. The size of the sample of water would have to be sufficient to yield at least 25 mg of ABS in order to give consistently satisfactory results in obtaining the infrared spectrum. This means that, for a sample of water which contains about 0.2 ppm of ABS, 30 gal would have to be run through the column.

Studies which the association has made to date indicate that activated carbon of a special type is suitable for use in this method. In checking the completeness with which the activated carbon would remove ABS from dilute solutions, ABS tagged with radioactive sulfur was used. For a 10-ppm solution, 99.5 per cent of the ABS was adsorbed on the carbon. Although the carbon eliminates some of the interferences, it does adsorb some rather tarry substances. The ABS and these substances are removed from the carbon quantitatively by several extractions (washing the column with an alcohol-benzene solution). It is then necessary to separate the ABS from the interfering substances before the infrared characterization can be made. The particular chemical property of ABS which permits its quantitative separation from the remaining interfer-

ing substances is its way of reacting with many organic cations to form water-insoluble complexes. The cationic surface-active agents of the quaternary ammonium type and other numerous organic amines react with ABS in this manner. This complex is insoluble in water but is soluble in chloroform or carbon tetrachloride. The ABS amine complex formed with 1-methyl heptylamine is easily used because the only benzene ring to show up in its infrared spectrum is the one in the ABS structure. When the ABS and interfering materials have been separated from the activated carbon by dissolving in the alcohol-benzene solvent, the solvent is removed by evaporation and the residue which contains the ABS is dissolved in a suitable quantity of water. The organic amine is added to the water solution and forms the complex with ABS which is insoluble in water but is soluble in chloroform or carbon tetrachloride. The solution can be used in the making of infrared spectrophotometer measurements. The parts per million of ABS is obtained by relating the amount of water in the sample being analyzed with the amount of ABS which shows in the spectrophotometer. By following these principles, a precise and unquestionable method may be developed. Cooperative testing in several laboratories is now in progress.

The significance of this analytical development is that it supplies a method for use where quantitative results are needed. Without such a method, many basic research projects would be greatly handicapped. The development is far enough along to permit the association to proceed with several other research projects in the field of water and sewage treatment.

### Future Projects

One of the association's future projects is to pursue a basic question which is yet unanswered: what is the fate of ABS in sewage treatment and in surface water supplies? There are few, if any, data on what happens in sewage treatment. A method of study would be to use ABS tagged with radioactive sulfur and follow its course throughout the sewage treatment process. Preliminary results soon to be published by the California Research Corporation indicate that, in the plant where their studies were made, there is a considerable breakdown of the ABS. The association intends to set up a more comprehensive study along these lines.

While there is every reason for the association to expect its first project to be successful, it is also planning a second project. It will study the possibility of developing a strain of micro-organisms to effect the complete destruction of ABS right in the sewage treatment plant. Success would take ABS completely out of the picture.

A third project will be to study the other components of the synthetic-detergent products as well as ABS in water treatment plants. What are the conversion products? Are they carried by the surface waters in such amounts or forms as to affect coagulation and sedimentation? It is in this project that the fate of the complex phosphates is to be investigated. How quickly do they convert to the simpler phosphates and what effect, if any, is encountered from the presence of the conversion products in surface waters? If the detergents cause trouble, how can that trouble be overcome?

The fourth project involves a study of the causes and prevention of frothing in sewage treatment plants. This project will follow up the work re-

ported by W. R. Gowdy (3), who showed that frothing is controlled in activated-sludge plants when sludge solids are maintained at relatively high levels. He suggests the possibility that frothing is caused by something that happens right in the aeration tank itself. The association would base its research project on this and other information which has appeared. This project is, of course, of special interest to the association because synthetic detergents usually become headline material when frothing occurs.

### Conclusions

A glance at population growth trends indicates that water supply and waste water disposal will become increasingly important in the near future. Increasing amounts of waste will have to be handled with the same flow of water in streams. At the same time there will probably be greatly increased water requirements. It is axiomatic that municipal sewage will increase in quantity. Without considering detergents at all, it is safe to predict that sewage will become more complicated. New techniques will be developed for determining the kinds of pollution, and new treatments will be found to eliminate any detrimental effects. The situation presents a challenge which must be met by sanitary engineers, chemical engineers, chemists, and all those whose careers are involved with water supply and waste water disposal.

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## Preliminary Report on a One-Hour Presumptive Test for Coliform Organisms

Gilbert V. Levin, Venton R. Harrison, and Walter C. Hess

*A contribution to the Journal by Gilbert V. Levin, Civ. Defense Repr., formerly Public Health Engr., Dept. of Public Health, Dist. of Columbia; Venton R. Harrison, Bacteriologist, School of Medicine, Georgetown University, Washington, D.C.; and Walter C. Hess, Prof. of Biochemistry, School of Medicine, Georgetown University, Washington, D.C.*

ONE of the paramount problems in the field of public health results from the long time lapse between inoculation and completion of bacteriological examinations. In controlling the quality of public water supplies, for instance, 48 to 72 hr must elapse before results of confirmed or completed bacteriological examinations can be obtained by standard methods (1). During that time, waterborne disease could be spread throughout a community. Although methods have been proposed to shorten the time interval, no methods have been devised to drastically reduce it, because all require either sufficient cell multiplication to yield direct visual evidence of colonies for identification or of production of gas.

If the disadvantages of current methods for the bacteriological examination of water are to be overcome, it is necessary to develop a tool capable of measuring such minute dimensions that a small number of cells present in a water sample can be detected and identified with little or no loss of time for incubation. Furthermore, the method must be simple enough to be used as a routine laboratory test.

Perhaps the most finely dimensioned investigative tools known at the present time consist of radioisotopes and

the instruments for their detection. The senior author conceived the idea of applying these sensitive techniques to the problem of detection and identification of bacteria. This possibility was strengthened by the extensive fundamental research of Cowie, Bolton and Sands (2, 3), who used radioisotopes in metabolic studies of *Esch. coli*. The District of Columbia Department of Public Health and the Georgetown University School of Medicine decided to undertake a joint research project. The United States Atomic Energy Commission provided financial support. In June, 1955, work was begun at the university in Washington, D.C. This paper describes the progress and status of the investigation.

### Experimental

The standard method for the identification of coliform organisms requires that there be production of gas from lactose (1). If the lactose is labeled with the radioactive isotope  $C^{14}$ , then the carbon dioxide produced should include some of the labeled carbon that could be detected and measured. Lactose labeled with carbon-1, obtained from the National Bureau of Standards (4), was used to prepare standard lactose broth. Test organisms were

inoculated into the broth and incubated with aeration. The carbon dioxide in the exhaust air was collected and examined for radioactivity after periods of time which were much less than the time required for the production of a visible bubble. The collection of the carbon dioxide was achieved by passing the exhaust gas through a paper fiber pad moistened with a saturated solution of barium hydroxide.

exhaust gas from the culture was bubbled through a saturated solution of barium hydroxide and the precipitated barium carbonate was filtered, dried, and counted for radioactivity. It was found, however, that a significant amount of the radioactive barium carbonate remained in solution. The pad method was developed to reduce this loss and the sensitivity of the test was greatly increased.

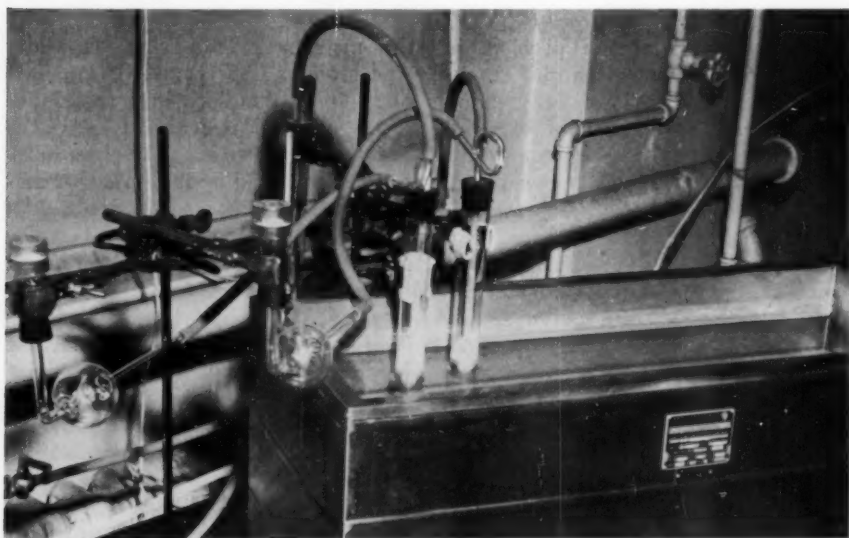


Fig. 1. Apparatus for One-Hour Presumptive Test

*Air is bubble-metered through oil in the tubes behind water bath incubator and diffused through radioactive lactose broth in the tubes in incubator. The exhaust gas is passed through vapor traps and collected on barium hydroxide-impregnated pads in holders at left.*

The apparatus used for the aeration, culturing, and carbon dioxide collection forms a simple air train, which is shown in Fig. 1. At selected intervals, the pad was removed from its holder and dried under an infrared lamp. The radioactivity collected on the pad was then counted in a gas-flow Geiger counter attached to a scalar (see Fig. 2). In the first experiments, the

In a typical early experiment, 10 ml of standard lactose broth containing 0.5 per cent 1-C<sup>14</sup> lactose (1.79 microcuries per milligram) were inoculated with approximately 26 *Esch. coli* cells, as determined by plate count of the inoculum suspension. The tube culture was incubated at 37°C with constant aeration. The exhaust gas was diffused through barium hydroxide so-

lution by means of a tube with a fritted-glass tip. The tube containing the barium hydroxide was removed hourly and the contents filtered through a membrane filter that was then dried and measured for radioactivity. The activity was expressed in counts per minute as shown in Table 1. When the total activity exceeded twice the background count the level was considered significant for a positive determination. This occurred within 2 hr. The incremental decrease in the fourth and fifth hours probably repre-

some radioactive contamination was present at the start of the run, as indicated by the 0 hr counts. It was found that these counts were produced by the breakdown of trace impurities in the lactose. These spurious counts can be substantially reduced by aeration of the broth prior to inoculation.

After a number of confirmatory repetitions of this experiment, it was decided to try the method on raw Potomac River water as the first practical test. Water was taken from the river at a point in downtown Washington

TABLE 1

*Presumptive Test of Sample Containing Approximately 26 Esch. coli*

Time hrs	Radioactivity*—cpm†	
	Increment	Cumulative
1	9	9
2	23	32‡
3	197	229
4	79	308
5	25	333
6	313	646
7	2,291	2,937
8	3,431	6,368

\* Radioactivity is measured above a background of 29 counts per minute.

† The abbreviation "cpm" stands for counts per minute.

‡ Point of presumptive determination.

sents a lag phase with resumption of multiplication occurring during the sixth hour.

Table 2 presents results obtained using the fiber paper pad to collect the radioactive carbon dioxide. The inoculum consisted of approximately 125 *Esch. coli* cells, as determined by plate count. The organisms were inoculated into only 5 ml of the 1-C<sup>14</sup> lactose broth so that the remaining 5 ml could serve as a control. The presumptive presence of coliform organisms was detected in 1 hr even though

TABLE 2

*Presumptive Test of Sample Containing Approximately 125 Esch. coli*

Time hr	Radioactivity of Test*—cpm†		Radioactivity of Control*—cpm†	
	Increment	Cumulative	Increment	Cumulative
0	106		99	
1	172	172‡	67	67
2	309	481	38	105
3	1,154	1,635	36	141
4	4,075	5,710	36	177
5	12,579	18,289	27	204

\* Radioactivity measured above a background of 21 counts per minute.

† The abbreviation "cpm" stands for counts per minute.

‡ Point of presumptive determination.

and was brought to the laboratory where five each of 10-ml, 1.0-ml, and 0.1-ml portions were inoculated into standard (nonradioactive) lactose broth. An equal volume (55.5 ml) of the same sample was filtered, and the filter membrane was removed and immersed in a test tube containing 5 ml of 1-C<sup>14</sup> standard lactose broth. A sterile control was run with this tube. All tubes were incubated at 37°C. The two tubes containing the 1-C<sup>14</sup> lactose broth were aerated and the carbon dioxide in the exhaust gas was col-





Fig. 2. Counting of Radioactivity

*Planchet containing dried pad is being placed in gas-flow counter. Scaler is seen at the left. Tank on floor supplies helium to counter.*

lected by the pad method. At short intervals, the pads were replaced with fresh ones, and the exposed pads were dried and counted for radioactivity. The fifteen tubes run by the standard method were periodically examined for gas. The first pad was removed after 30 min and demonstrated a radioactivity far in excess of that needed for a positive determination. The results of the tests are shown in Table 3. After 10 hr of observation, no gas had yet appeared in the *Standard Methods* test tubes. The tubes were then incubated overnight, and, upon examination 24 hr after inoculation, gas was seen in all tubes.

#### Discussion

The ability of the method to reduce significantly the time required to de-

termine the presumptive presence of coliform organisms has been demonstrated experimentally.

Theoretical calculations based on respiration rates of *Esch. coli* in standard lactose broth and the specific activity of  $C^{14}$  indicate that less than 20 cells can be detected in 1 hr with the present counting equipment. This assumes no bacterial multiplication during that period, and is not concerned with whether the organisms are in lag or growth phase.

The means of collecting the evolved  $C^{14}O_2$  have been frequently changed in the course of the work as better methods were developed. There is believed to be much room for further refinement, which will correspondingly increase the sensitivity of the test. Pending selection of what seems to be the

best collection method on which to standardize, the quantitative aspect of the test has not been stressed. Quantitative interpretation should not be difficult, however, once this standardization has been made. The slope of the cumulative radioactivity evolved as  $C^{14}O_2$  shows whether the organisms are in lag or growth phase, and the

required for a single quantitative presumptive coliform test, the 1-hr method will use only one test portion.

It seems likely that the method used in the rapid test can also be applied to develop a confirmatory test for coliform organisms, and this phase of the investigation will be pursued in the near future. Other work will include an attempt to use  $S^{35}$  in a variation of the method described to hasten the determination of the total number of bacteria in a water sample. Because  $S^{35}$  has a specific activity advantage over  $C^{14}$  of 10,000, it is likely that a single bacterium could be detected in a few minutes.

The rapid method should find use in other fields where bacteriological identification, culturing, or control is important, such as the milk and food industries, the sterilization industry, bacteriological warfare countermeasures, and medical diagnostic laboratories. The low order of radioactivity used does not require special safety equipment or more than elementary precaution by personnel.

### Summary

A simple presumptive test for coliform organisms which employs radioisotope techniques to produce results within 1 hr has been described. Statistical comparisons of the new method to the standard method are not yet available. It is believed that the method might also be used to produce confirmatory results within an additional hour. Variations of the method promise to permit similarly rapid determinations of other types of bacteria. The method should find wide application in public health work, industry, bacteriological warfare countermeasures, clinical medicine, and other fields.

TABLE 3

*Comparison of Radioisotope and Standard Methods Tests on Raw Potomac River Water*

Radioisotope Method				
Time min	Radioactivity of Test <sup>a</sup> —cpm†		Radioactivity of Control <sup>a</sup> —cpm†	
	Increment	Cumulative	Increment	Cumulative
30	1,598	1,598‡	28	28
60	1,578	3,176	23	51
95	2,428	5,604	18	69

Standard Method			
Time hr	Visual Evidence of Gas		
	Dilutions		
	10 ml	1.0 ml	0.1 ml
4	-----	-----	-----
6	-----	-----	-----
8	-----	-----	-----
10	-----	-----	-----
11-24	+++++	+++++	+++++

<sup>a</sup> Radioactivity was measured against a background of 22 counts per minute.

† The abbreviation "cpm" stands for counts per minute.

‡ Point of presumptive determination.

number of organisms present in the test portion is then directly proportional to the counts evolved per minute. If semilog plots are made of the cumulative activity as a function of the time of experimental data cited herein these characteristics are evident. Instead of the multiple number of tubes

### Acknowledgment

Particular acknowledgment and thanks are expressed to D. B. Cowie, Department of Terrestrial Magnetism, Carnegie Institution of Washington, for his early encouragement and continuing interest in this work.

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## Discussion—Report on Loss in Carrying Capacity of Water Mains

E. Shaw Cole

*A discussion prepared by E. Shaw Cole, Vice-Pres. & Chief Engr., The Pitometer Assoc., New York, N.Y. The report, presented by T. E. Larson at the Annual Conference, Chicago, Ill., was published in the November 1955 Journal, Vol. 47, p. 1061.*

THE report by T. E. Larson, published in the November 1955 JOURNAL, treats the subject of roughness of the pipe interior on the basis that this is associated with carrying capacity. From this starting point it is logical to review the various means of measuring roughness, and this, in turn, leads one into the fascinating but broad field of fluid mechanics.

Although it is realized that some of the work done in the field of fluid mechanics is presented by Larson only for the record and will not be pursued, there is a danger that others who follow will be misled by the theoretical considerations presented in simplified form. Of particular danger is the implication that the ratio of mean velocity to center velocity, otherwise known as the "velocity factor," may be used as a measure of carrying capacity. The report states that "although this is an approximate determination, it correlates surprisingly well with Hazen-Williams C." The author refers to his Fig. 2 which shows a series of curves for various sizes of pipe and for different velocities and includes 15 points which presumably were used as a basis for drawing the curves. The curves as presented give the impression of authority so that it would be easy for an inexperienced person to be misled.

The theoretical analysis of the velocity distribution in a pipeline is one of

the most fascinating studies in fluid mechanics, particularly to those involved in water works. The relationship of the Hazen-Williams C to the ratio of mean velocity ( $V_m$ ) to center velocity ( $V_c$ ) can be shown by the formula:

$$\frac{V_m}{V_c} = \frac{1}{1 + 1.442\sqrt{1090/C^{1.85}R^{0.15}}}$$

This is developed in John K. Venard's excellent book on elementary fluid mechanics (1) which, in turn, refers to Bakhmeteff's *The Mechanics of Turbulent Flow* (2).

Curves obtained from this formula have been plotted in Fig. 1 of this discussion. The heavy solid line is for R of 553,000, which corresponds to a velocity of 3.0 fps, a diameter of 24 in., and a water temperature of 68°F. The light dotted line is for R of 1,105,000, corresponding to a velocity of 3 fps and a 48-in. pipe. It should be noted that, since the formula was developed from the turbulence structure and without regard to the texture of the pipe wall, it is equally valid for smooth and rough pipes.

In Fig. 1, 365 points have also been plotted. These were obtained from tests made in ten large cities. Many additional data are available, but time has not permitted their use. The data presented, however, are sufficient to

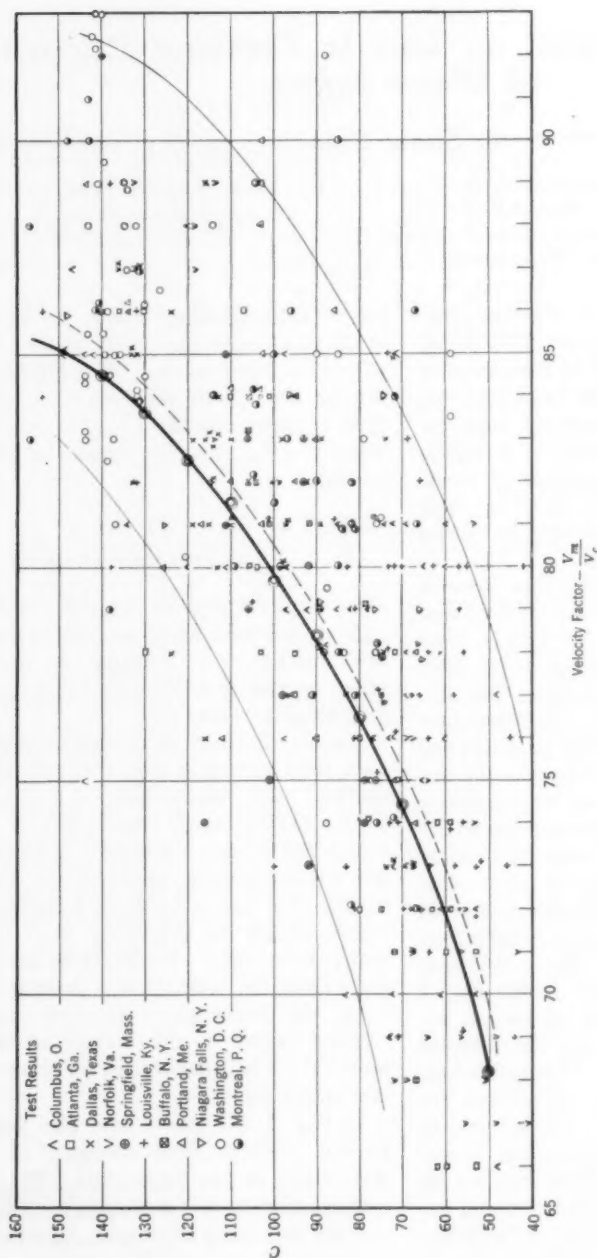


Fig. 1. Relationship of Hazen-Williams C to Velocity Factor

Two theoretical curves have been plotted from the formula. For the heavy solid line,  $R$  is 553,000, corresponding to a velocity of 3 fps and a pipe diameter of 24 in. For the light dashed line,  $R$  is 1,105,000, corresponding to a velocity of 3 fps and a pipe diameter of 48 in. A limited amount of data is given, but the wide possible variation between velocity factor and the Hazen-Williams C is indicated. The scatter of test points is because of the many variables involved. The symbols indicate data from field tests made in the ten cities listed above.

emphasize that there can be a wide variation from the theoretical relationship between  $\frac{V_m}{V_c}$  and the Hazen-

Williams  $C$ . At a  $\frac{V_m}{V_c}$  ratio of 0.81, for example,  $C$  varies from 53 to 137, or, if several of the wildest points are discarded, from 70 to 120—a range of 50 points. The theoretical value is 105. At a  $\frac{V_m}{V_c}$  ratio of 0.83, the  $C$  coefficients have a range of 75 points (70–145), and at 0.78 the coefficients have a range of 70 points (60–130).

The wide scatter of test points is, of course, due to the many variables that exist in field testing. The location of the gaging point in relation to obstructions, fittings, take-outs, or put-ins, alone will account for many of the

wild points, while variations in velocity and in the condition of pipe throughout its length will account for others.

There is no question here of the theoretical relationship between  $\frac{V_m}{V_c}$  and the Hazen-Williams  $C$ , which the many test points confirm quite well. But of special significance is the evidence that the relationship may be dangerously misleading if the data are not carefully obtained and critically examined.

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## Corrosion of Brass by Chloramine

—T. E. Larson, R. M. King, and L. Henley—

*A contribution to the Journal by T. E. Larson, Head, Chemistry Subdiv.; R. M. King, Asst. Chemist; and Laurel Henley, Asst. Chemist; all of the State Water Survey, Urbana, Ill.*

**C**ORROSION manifests itself in many ways. Some of these ways are striking, some insidious; some are costly, some of purely nuisance value. Its mitigation is often accomplished by trial and error methods, other times by search for causative or preventive factors. Knowledge of corrosion is usually increased, however, by whatever means of mitigation are adopted.

### Wire Drawing

In valves, impingement corrosion may be severe and is commonly referred to as "wire drawing." Impingement corrosion occurs under conditions of very high velocity and it results in a metal surface which appears to have been impinged or pitted by a high lateral turbulent velocity. Copper-zinc alloys, as well as copper, are notoriously subject to impingement attack. Not a new phenomenon, wire drawing in ordinary household faucet seats has existed as a nuisance type of corrosion not generally prevalent or recognized.

Impingement attack has frequently been reported as the result of high velocity with entrained air in the fluid stream, causing impingement of gas bubbles on the metal surface. From the results of this study, it might be concluded that this theory is not corroborated. It is more probable, how-

ever, in the type of water used in this study, that the influence of dissolved oxygen is negligible (1), compared to that of chloramine.

During the year 1952-53, there was an increase in the number of complaints and, in some communities, such as Champaign-Urbana, requests for information on how to avoid frequent replacement of faucet seats due to wire drawing were received from home owners, hotel maintenance men, apartment buildings, schools, and plumbing contractors. One of the larger plumbing contractors reported that during the years 1948-50, his annual orders for faucet seat replacements had been about 500, and that suddenly in 1951-52 they increased to 1,500. No data were available on the geographic location of the replacements.

In Champaign-Urbana the water supply was changed to a new well field in 1951, but with the possible exception of a somewhat lower ammonia content, the quality of the water was not greatly affected.

At about this time, to facilitate iron removal, the procedure for treatment had been revised to provide chlorination before filtration, whereas formerly split chlorination had been practiced. The prechlorination now provided more than 2 ppm chlorine residual in the water leaving the plant. This residual

was established as chloramine, with no free chlorine present. The revised treatment, however, altered conditions in the distribution system so that both dissolved oxygen and chlorine residuals were recorded at the ends of the distribution system. Formerly, chlorine residuals were virtually absent in the outer part of the system.

Tests were made using cotton plug filters to determine whether the new treatment was releasing particles of silt from deposits and slime growths in

TABLE 1  
*Tap Water Composition*

Item	Amount	
	ppm	epm*
Iron (Fe)	trace	
Manganese (Mn)	trace	
Calcium (Ca)	60.0	3.0
Magnesium (Mg)	24.0	2.0
Sodium (Na)	46.0	2.0
Ammonium (NH <sub>4</sub> )	0.6	0.03
Silica (SiO <sub>2</sub> )	19.0	
Fluoride (F)	0.3	
Chloride (Cl)	6.0	0.20
Nitrate (NO <sub>3</sub> )	0.2	
Sulfate (SO <sub>4</sub> )	9.6	0.20
Alkalinity (as CaCO <sub>3</sub> )	330.0	6.60
Hardness (as CaCO <sub>3</sub> )	250.0	5.00
Dissolved oxygen	6.0	

\* Equivalents per million.

the mains, thereby possibly causing such particles to lodge in faucet seats and promote the inception of wire drawing. No significant amount of silt content was noted at the ends of the system. An analysis of the tap water is shown in Table 1. These readings were taken at a temperature of 55°F and a pH of 7.4.

In June 1953 a series of six faucets was installed at the water plant. These

faucets were adjusted daily to provide a specified drip rate. Failure was indicated by inability to stop the flow of water. Four of the faucets had pressed-fit removable seats of yellow brass and two were equipped with seats of Monel metal. At the end of 52 days all four of the brass seats had failed, but neither of the Monel seats, which were seats No. 5 and 6 in Table 2. Two of the brass seats, No. 14 and 15, having an adjusted drip rate of 200-400 ml per minute, failed within 14 days, whereas the other two, No. 16 and 17, having an adjusted drip rate of about 40 ml per minute, failed within 27 days.

No attempt was made to use stainless steel in this experiment. The University of Illinois' maintenance experience had found that it was no more satisfactory than brass, although Monel metal proved satisfactory at points where severe wire drawing had been continuously experienced. During this period a large hotel in Urbana attempted to use stainless steel for faucet seat replacements but also found it to be no better than brass.

In 1949-52, information appeared which indicated that chlorine and chloramine accelerated impingement attack and cavitation (2-5). It became important, then, to determine whether air, free CO<sub>2</sub>, or chloramine was the cause of the experiences noted in Champaign-Urbana. There was no reason to believe that a greater amount of CO<sub>2</sub> was present in the water. Furthermore, CO<sub>2</sub> or chlorine, could not be eliminated from the water except at prohibitive expense. Also, because the major manufacturers of the faucets already in service did not choose to make Monel faucet seat replacements available, it became neces-

sary to learn if a plated faucet seat would be satisfactory.

### Testing

An opportunity was offered to test faucet seats in the University of Illinois Vivarium building, where the city water was dechlorinated by passing through activated carbon and re-aerated to produce a high dissolved-oxygen content. Water leaving the activated carbon filter was of low dissolved-oxygen content. In the meantime, in December 1953, the chlorine residual at the city water plant was reduced to 1.3 ppm. Three series of tests were made at this location, using in each case the three types of water. Specified drip rates were adjusted daily except Saturday and Sunday. At these times determinations were made for chlorine and dissolved oxygen.

In the first test period, with water of no chlorine residual, faucet seats No. 1, 3, 5, and 9, whether brass or Monel, lasted for the entire 41 days of the test. Faucet seat, No. 2, in the chlorinated water, was plated electrolytically with 0.006 g silver.\* This seat lasted for the 41 days as well as the Monel seat No. 6. Two brass seats, No. 1 and 3, which did not fail in the absence of chloramine, lost weight in the same order of magnitude as those which failed with chlorinated

water. In this test, two faucets, No. 9 and 10, were installed with a movable seat and rigid washer.

The next period of tests lasted 91 days. Seat No. 10 was replaced by seat No. 11 and two faucets with red brass seats, No. 7 and 12, were included. Again the Monel and the electrolytically plated seats withstood the chlorinated water but the brass seats did not. Seat No. 1, in dechlorinated water with low-dissolved oxygen, failed after 132 days, the combined length of the two test periods. Seat No. 3, in dechlorinated and re-aerated water, failed at the same time.

The last period of tests ran for 147 days. The seats which had not previously failed were again installed and three additional seats were prepared. One of these, No. 18, was silver plated electrolytically. The other two, No. 19 and 20, had been dipped in silver cyanide to produce a silver coating. These seats failed in 47 and 72 days, respectively. They were then machined and replated. Seat No. 19 was plated electrolytically and was then referred to as No. 21. Seat No. 20 was plated by dipping again in silver cyanide and became No. 22. Sixty-three days after seat No. 20 had been redipped in silver cyanide, it again failed. The seat which had been electrolytically silver plated was still in service after 42 days. Experiments were concluded at this time. A summary of the results of these tests is shown in Table 2.

Brass seats in dechlorinated water with or without dissolved oxygen, lasted about three times as long as brass seats in the presence of chloramine at a concentration of 1 ppm. Red brass seats were found to be no better than yellow brass in chlorinated

\* This process consisted of a 3-5-sec dip in 135 ml of  $H_2O$  containing 1 g of  $HgCl_2$  and 0.5 g of  $NH_4Cl$ . The seat was immediately rinsed in warm water and then dipped again for 3-5 sec in 135 ml  $H_2O$  containing 9 g of  $KCN$  and 0.5 g of  $AgCN$ . An electric current of 0.5 amp (direct current) was applied for 10-15 min, with Ag or Pt electrode at a distance of 0.5 in. from the seat, in 135 ml  $H_2O$  containing 4.5 g  $KCN$ , 4.85 g  $AgCN$ , and 5.0 g of  $K_2CO_3$ .

TABLE 2  
Summary of Results\*

Seat No.	Material	Avg. rate of drip mi/min	DO ppm	NH <sub>4</sub> Cl (as Cl <sub>2</sub> ) ppm	Wt. loss g	Service days
14, 15	brass	130-210	8	2+	0.04-0.06	14
16, 17	brass	20	8	2+	0.019-0.025	27
4, 13	brass	33	6	1	0.022-0.028	32, 35
12	brass (red)	37	6	1		63
10, 11	brass	34	6	1		34, 56
19, 20, 22	brass— silver plated (dipped)	35-36	5	1	0.033	72
					0.032	47
2, 18, 21	brass— silver plated (electrolytic)	28-35	5	1	0.008	63
					0.024	147†
					0.030	119†
6	Monel	33	5-8	1-2+	0.0008	44†
1	brass	38	1	0	0.052	330†
3	brass	32	7	0	0.075	133
7	brass (red)	28	7	0		133
9	brass	29	7	0		278†
5	Monel	32	7	0	0.011	232†
						330†

\* All seats were rigid with movable washer except No. 9, 10, and 11.

† Seats still in service at end of testing.

water but appeared to be more serviceable in dechlorinated water. It was interesting to note that brass in dechlorinated water lost weight before wire drawing. The appearance of these seats was bright red, indicating dezincification.

### Summary

Electrolytically silver-plated brass faucet seats were satisfactory, but only when the plating was made on a clean surface and was complete enough to avoid weight loss. Seats No. 19, 20, and 22 were exposed for 5-30 min in 150 ml of water containing 1 g KCN and 1 g AgCN. Dipping in silver cyanide with no electric current did not provide a satisfactory plating.

Monel faucet seats were not subject to wire drawing. Although seat No. 6 had a weight loss of 0.0114 g, there was not even microscopic evidence of deterioration on the surface and no previous weight loss had been experienced. It is assumed that a small burr had been chipped off during removal with an Allen wrench.

It should be noted that the accelerated tests provided herein were quite severe, more severe, in fact, than the conditions usually encountered in normal household use. Where automatic flow regulators are employed or where careless handling is experienced, however, such conditions might exist.

It was concluded that the excessive replacement of faucet seats resulted from the presence of appreciable chloramine residuals in a greater portion of

the distribution system. The presence of dissolved oxygen in the water was not a contributing factor. The use of Monel or electrolytically silver-plated brass seats proved a satisfactory solution to the problem.

### Acknowledgment

The authors are indebted to Frank Amsbary and to T. R. Dyer for permission and assistance in establishing the first series of tests at the filtration plant. Consent was also graciously provided by S. C. Kendeigh to conduct tests in the University of Illinois Vi-varium Building.

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## Chronic Toxicity of Cadmium and Hexavalent Chromium in Drinking Water

— C. F. Decker, C. A. Hoppert, and R. U. Byerrum —

*A paper presented on Jun. 15, 1955, at the Annual Conference, Chicago, Ill., by C. F. Decker, Research Instructor; C. A. Hoppert, Prof. of Chemistry; and R. U. Byerrum, Assoc. Prof. of Chemistry; all of the Dept. of Chemistry, Michigan State University, East Lansing, Mich.*

**A**T the suggestion and endorsement of the AWWA, the Dept. of Chemistry, Michigan State University, East Lansing, in October 1953 filed an application for a research grant with the National Institutes of Health to study the toxicity of cadmium and hexavalent chromium in concentrations that may be expected in public water supplies. The project received favorable action from the National Institutes of Health study group and was financed through a grant starting September 1954.

The AWWA set up an advisory committee, whose services could be used at the discretion of the researchers. Semiannual reports have kept the committee informed of progress.

### Introduction

Several investigators have indicated the necessity for new experimental data upon which to base values for the maximum allowable concentrations of cadmium and hexavalent chromium in drinking water.

Cadmium has been known to be a highly toxic element for many years and a considerable amount of information is available concerning its pharmacology. Muehlberger, in a recent review (1), has emphasized the impor-

ance of additional experimental evidence on chronic cadmium toxicity in both animals and man.

One experience of long-term exposure to cadmium in drinking water was reported by Princi (2). This author studied several individuals who had consumed water containing 0.047 ppm cadmium. No adverse effects were noted in these individuals. Haney (3) has also emphasized the need for a drinking-water standard and expressed the belief that the maximum allowable concentration may have to be based upon the discoloring effects of cadmium on teeth. Welsch and Lieber (4) reported cadmium contamination of ground water in the Long Island, N.Y., area in concentrations between 0.05 and 3.2 ppm. These concentrations were, however, found in water not used for drinking purposes.

### Present Study

The present long-term study with albino rats and dogs covers a cadmium concentration range between 0.1 and 10.0 ppm. An analysis of the data after 6 months of exposure shows the following results:

1. The ingestion of cadmium in drinking water in these concentrations



had no effect on the body weight or growth rate of the albino rats.

2. There was no adverse effect on the food consumption or water intake.

3. No significant variation was observed in the hemoglobin content of the blood, either in the erythrocyte count or the leucocyte count.

4. The results for the dogs were essentially the same.

The toxicity of chromium has been extensively investigated but its chronic toxicity at concentrations likely to occur in potable water supplies has not been established. The present work is concerned with the chronic toxicity of hexavalent chromium in a range of 1-25 ppm (expressed as  $\text{CrO}_4^{=}$ ). The results of the work after 6 months of exposure showed no adverse effects with respect to growth

rate, food consumption, or water intake, but there was an apparent slight reduction in the hemoglobin value of animals ingesting water of the 25-ppm concentration.

### Conclusion

These results must be taken as tentative. A more complete evaluation is not possible until the end of the proposed long-term exposure period.

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## Maintenance Painting Procedures

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**A. L. Kimmel**

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*A paper presented on Apr. 23, 1954, at the Nebraska Section Meeting, Lincoln, Neb., by A. L. Kimmel, Research Chemist, the Tnemec Co., Kansas City, Mo.*

**M**AINTENANCE painting concerns everyone, from the small home owner to the owner of the largest industrial installation. It is almost impossible to give a proper procedure for maintenance, because so many factors come into play, the chief one being economics. Problems that occur are different in almost every case, and common sense practice, therefore, is one of the best rules to follow. For further study of the problem, a list of pertinent material is included in this paper (1-6). Generally speaking, however, good clean surfaces and well applied coatings of the proper type will result in a satisfactory job.

In judging the durability of a paint, conditions of exposure must be considered. Because these conditions vary, standards of durability also vary. In some cases, a year's effectiveness might be excellent durability, while in other cases, 3 years' would be very poor. Experience with the local conditions is the best criterion for judging a job, with past records used as a yardstick. In discussing maintenance painting procedures, surface preparation and the paint system must be considered.

### Surface Preparation

When preparing steel for painting, the steel should be as clean as possible. All rust, loose mill scale, and grease

should be removed. The extent to which rust and mill scale are removed depends on the surrounding equipment and cost. Sandblasting to gray or white metal is always best, though sometimes not practical. In most cases, scraping or wire brushing will be done and, if it is properly executed, it is very satisfactory. Close attention must be given to deep pits and rivet heads, because these are spots most often missed in cleaning operations. Oil and grease spots can be removed by wiping with cloths dipped in a solvent such as mineral spirits or turpentine.

For repaint work, all loose paint must be removed and the surface wiped dust free. Areas where the paint is bad down to the bare metal must be thoroughly wire brushed and spot-primed. A good general rule is that if 50 per cent of the old paint is off to the bare metal, a complete coat of primer is advisable.

Concrete and masonry surfaces should be wire brushed and then dusted to remove all loose material. If the concrete is very dense, a muriatic acid etch is usually advisable, followed by a wash with plenty of water. The surface must be dry before the paint is applied. It should be mentioned, too, that with concrete and masonry, the paint sticks by mechanical bond rather than natural adhesion. The surface, therefore, must

be porous enough for the paint to penetrate and create the bond.

For repaint work on concrete and masonry, all loose paint must be removed. Oil-base paints will work well over old, tightly adhering oil base or rubber emulsion-type paints, but not over water-cement type paints. Water-cement or rubber-emulsion paints will adhere to almost any type of old paint providing it is not loose, flaky, or dusty. Repaint jobs of this type require very good surface preparation.

New plaster surfaces should be checked for alkalinity and moisture. Paint manufacturers' recommendations should be used as a guide. Repainting old plaster requires that the surface be clean and dust free, with all loose paint removed. Rough sanding or scraping should be used first to remove loose paint, and then fine sanding should be done to level the surface. Surface dust must be removed following the sanding operations.

Wood surfaces must be clean and dust free, and all dirt and loose paint must be removed. Oil spots should be cleaned off with a solvent and pitch spots should be sealed. Even the very best paints will not stick to a dirty, dusty surface, and the most economical job is the one done correctly. Money spent in proper surface preparation is insurance for an effective paint job.

### Paint Systems

Primers are of more than one type. In selecting the proper one, the surface to be coated is the most important consideration.

#### Steel

Primer for steel should have the following characteristics:

1. Ease of application
2. Good adhesion
3. Rust Inhibition

4. Proper viscosity to produce the required film thickness

5. Durability enough to remain unaffected until the finish coats are applied

6. A good surface on which the finish paint film will adhere, and

7. Proper drying characteristics.

The purpose of the primer is to protect the steel and to afford a bond between the steel and the finish coats. Because no paint system is completely impervious to water and moisture, the primer must have enough rust-inhibitive power to eliminate rusting under blisters and the film itself. A good primer must also retard rusting on the steel when the finish system is scratched or abraded to bare metal. It should not allow corrosion to undercut the paint film. In many instances, a primer is put on and several weeks pass before the finish coats can be applied. It is a definite advantage, therefore, to have a primer durable enough to resist the elements. Improper drying will, in some instances, cause premature paint failure. With dusty or humid conditions, a fast-drying primer is superior to a slow-drying type. Slow-drying, oil-type primers with high penetrative action are usually best for outdoor use and for places where it is impossible to get complete cleaning of the surface.

A primer with all these features will give good service under most conditions. For highly specialized applications, it is sometimes necessary to resort to special formulations, but these cases are exceptional.

#### Concrete, Masonry, and Plaster

In dealing with concrete or masonry, the proper primer will depend entirely on the surface involved. Because the bond is mechanical, the prime coat should perform the following:

1. Penetrate the pores and form a good bond
2. Seal off the surface, and
3. Present a good bonding surface for succeeding coats.

The best recommendation that can be made for treating these surfaces is to follow the manufacturers' instructions to the letter. When oil-base coatings are used on concrete or plaster surfaces, especially in new work, neutralization is usually necessary. Alkaline surfaces tend to destroy the bond and will cause pulling and flaking of oil-base coatings. With most water-base or rubber-base coatings, neutralization is unnecessary. Another factor is the moisture content of the surface. Oil-base and solvent-type rubber-base coatings will not bond well to damp surfaces, although water-base coatings will. Alkalinity and moisture must always be checked before application of the prime coat.

### *Wood*

For wood surfaces, the type of prime coat is dictated by the exposure and the finishing system. On exterior wood, a good house paint thinned with up to 25 per cent raw or boiled linseed oil is usually the best primer. It is also a good base coat for trim enamels. For interior work, a good enamel undercoat should be selected. Here again, manufacturers' recommendations are the best guide.

### **Finish Coats**

In considering finish coats for the above surfaces, the selection will depend entirely on the conditions of exposure and the appearance desired. Because it is almost impossible to give exact recommendations on finish coats without having complete data concern-

ing the job, no details of products will be given.

### **Maintenance Painting**

If a careful study were made of paint jobs and the results were tabulated, the conclusions would probably show three main reasons for paint failures. In the order of their importance they are: [1] lack of proper surface preparation; [2] improper application; and [3] improper choice of material for the job. It is the foundation of a house or building which determines the life of the structure, and the same is true with paint. The best paint in the world cannot adhere to a poorly prepared surface.

Correct application is also essential. A good uniform coat of paint is always superior to a thick, irregular film because a uniform film deteriorates evenly and presents a better surface for repaint. Also, heavy, unevenly applied paint has a tendency to produce pulling and checking.

Improper choice of materials for the exposure involved is another cause of premature paint failure. Where there is any doubt, the manufacturer should be contacted. The paint manufacturers maintain laboratories for the evaluation of coatings. These facilities are for customer service, without charge, and they should be utilized.

One way to avoid an improper choice of materials is to keep good records of paint jobs. Practical experience is one of the best references and is always reliable.

Another approach that has proved itself in practice is to consider a particular job as a system rather than as individual coats of paint. If a paint job is to be durable, the primer and finish coats must work together. Here again, experience on particular jobs

will indicate the effective life of the paint job.

An important point which is sometimes overlooked by the maintenance painter is the drying time of finishes. The drying or recoat time indicated on the label is usually given for standard or ordinary conditions (77°F and 65 per cent humidity). Lower temperatures or higher humidities will usually slow the drying and increase the time necessary between coats. The lifting of primer or finishes by succeeding coats can usually be directly traced to insufficient drying time between coats or to surface contamination prior to priming.

When coating machinery or equipment, it should be remembered that the painted surface will show the same defects as the unpainted surface. Paint will not fill holes, cracks, or pits, so these must be properly filled before priming or painting. If the sharp edges of previous paint are not sanded smooth, they will show through the new paint job.

### Conclusions

The following points should be considered in applying new paint:

1. The cleaner or better prepared the surface, the better the paint job.
2. Good quality paint is always the cheapest in the long run.
3. For both primer and finish coats, the type of paint which is best suited for the job should be selected.

4. Past experience or manufacturers' recommendations should be used as a guide whenever possible.

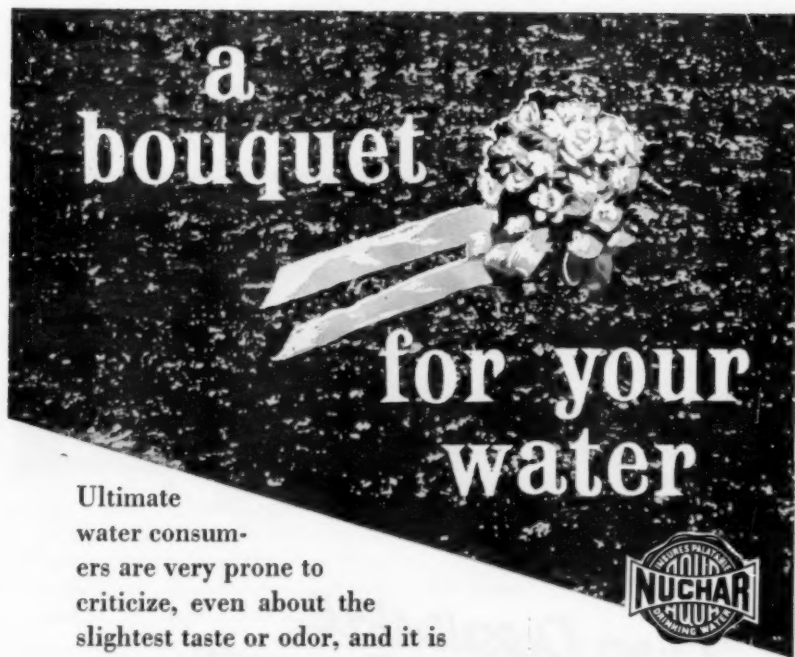
5. Each coat of paint, from primer to finish, should be uniform rather than irregular.

6. Cleanliness of both structure and painting equipment is vitally necessary for a good job.

It has been the author's experience that no paint manufacturer ever tries to make bad paint. For certain jobs, however, some paints are better than others, and this selection is sometimes difficult to make. All other factors being equal, however, experience is the best criterion for judging which paint should be used.

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6. *Why Paint Peels—Causes and Prevention*. The Heckel Publ. Co., Philadelphia, Pa. (1951).



Ultimate water consumers are very prone to criticize, even about the slightest taste or odor, and it is seldom that water plant operators receive 'bouquets'. However, by using AQUA NUCAR activated carbon for efficient taste and odor control, water plant operators can successfully reduce complaints. Perhaps they will even receive an occasional 'bouquet' for the sparkling water with the 'cut-diamond' look!

Yes, water plant operators across the country and around the world, with every conceivable water purification problem, depend on NUCAR Activated Carbon to cut down complaints and build up good will by delivering good-tasting water.

If you have not already taken advantage of Industrial's complimentary Threshold Odor Surveys, call us immediately.

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**TRIDENT****"BALANCED DESIGN"****MEANS****QUIET, DEPENDABLE  
OPERATION**

**T**hree problems that give meter superintendents gray hairs . . . noisy meters, broken discs and premature failures . . . have as their primary causes turbulence, interference, and improper motion of the disc piston. Here's how Trident meter's "balanced design" eliminates these faults:

The Trident disc is axially controlled. The thrust roller . . . Neptune "first" . . . guides the disc in the exact path necessary for smooth, balanced flow of the water. No sloppy or eccentric motion to cause noise, disc breakage or excessive wear. Inlet

and outlet ports, and the casing itself are carefully designed for smooth, uninterrupted flow of water. There is no turbulence caused by water circulation up through the gear train and stuffing box . . . these are permanently lubricated and sealed from the path of the water.

We believe the Trident meter, if properly installed, is the quietest, most dependable meter you can buy. It's one of the many reasons why more Trident meters have been bought in the past 50 years than any other meter.

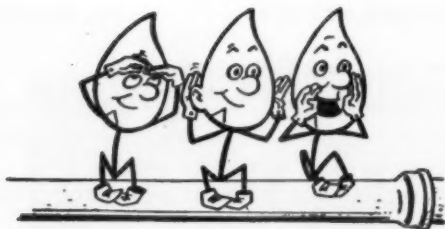
**NEPTUNE METER COMPANY**

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*Branch Offices in Principal  
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## Percolation and Runoff

### Happy Diamond Jubilee Year!

And though AWWA won't actually be 75 until Mar. 29, and though that won't come till a day later than it did last year, who waits until midnight for his New Year's snort? Besides, with 1956 officially (by P&R) designated "Every-Member-Get-a-Member Year," the staff is rather anxious to get at the job of processing more than 10,000 new member applications, thus to spread it over as much of the year as possible. As for you, the earlier you start, the more prospects you will have—although there should be plenty to go around. After all, AWWA's present 10,000-plus members represent far fewer than 10,000 different organizations—and certainly there should be at least one AWWA member in each of the more than 18,000 water utilities now serving the US and Canada, at least one in each of 2,000 or more industrial plants which must develop or treat their own supplies, at least one in each of 500 or more colleges and universities offering engineering courses, at least one in each of 500 or more consulting firms, and at least one in each of 500 or more manufacturing firms catering to the needs of the field. And what better year to build up student membership, which has never even hit the 100 mark?

Not many years ago, Bill Orchard's guess that the Association might expect one day to reach a membership of

5,000 was dismissed as an excess of enthusiasm and, no more than six or seven years ago, the idea of 10,000 members was pretty generally pooh-poohed. Yet both those marks were passed easily and, now, with water problems increasing in number and complexity, who will say that even 25,000 members is not possible?

*Happy Every-Member-Get-a-Member Year!*

Speaking of happy news, we have been especially happy to note that the mighty atom is beginning to swing more and more weight in nonmilitary circles these days—and a little less secretly, too. The relaxation of the super-hush-hushery began last August when representatives of 72 countries got together in Geneva, under the auspices of the UN, to compare notes on their progress and problems in the application of atomic energy to peaceful uses. It was the number of US atom secrets that were common knowledge among both our friends and notso-friends that convinced the AEC to let industry in on some of the more useful facts about this new tool. Actually, of course, the peaceful applications have been multiplying ever since radioisotopes were first released for medical research, and, even before the AEC's more liberal attitude, atomic radiation was being used in such various jobs as sterilizing drugs, destroying food bac-

*(Continued on page 36 P&R)*

(Continued from page 35 P&R)

teria, and hardening plastics. Meanwhile, Russian atoms had been harnessed not only to a 5,000-kw power plant, but to a nuclear milking machine, and throughout the world the best scientific minds were being applied to what President Eisenhower called "unfolding to the peoples of the world the bright promise of the benign atom."

To the water works field, the inception of the atomic age has been more of a threat than a promise, adding the hazard of radioactive pollution to all the other headaches of producing a safe water. But in thirsty California, such grandiose plans as the one which proposes pumping Columbia River water to the semiarid area south of Los Angeles seem a little more feasible in the light of atomic power. And all around our salty coasts, droughtbound cities can't wait to apply nuclear energy to the job of converting sea water to fresh. Perhaps the most direct application, though, is that suggested by the successful experiments of the US Army Corps of Engineers in using gamma radiation from radioactive substances to sterilize sewage and to decrease bacteria in swimming pools without activating, or leaving residual radiation in, the treated materials. There, with a little more refinement, we can see the water works disinfection plant of the future—a handful of radioactive cobalt aimed at the effluent of the filtration or pumping plant, Hiroshimashing the bacteria as they go by. Meanwhile, these future victims of atomicide are already being put on the radioactive spot by a new rapid method of coliform determination described by Gilbert Levin and colleagues in this issue (text page 75). And with more than 200 papers being presented at

EJC's nuclear energy congress in Cleveland in December, who can even imagine what may be cooking?

Not just new year this, but *Happy New Era!*

**Pilot project** in the establishment of short schools for Canadian water works men was a senior-operators' course held Oct. 17-21 at Toronto, under the auspices of the Ontario Dept. of Health Sanitary Engineering Div., of which A. E. Berry is director. Prime mover in the project was G. H. Strickland, superintendent of the water division of the Windsor Utilities Commission, who was chairman of the AWWA Canadian Section committee that originally recommended the program. Strickland assisted Dr. Berry in organizing the course and also participated as a lecturer, along with Dr. Berry and some 20 other experts in the water works field. The 5-day course consisted of 32 hr of lectures and demonstrations covering a wide variety of subjects essential for a fully qualified operator. It is expected that detailed study of this initial course will be made by provincial health departments and municipal officials throughout Canada, in order to determine the feasibility of similar courses in their areas—an idea that was inherent in the recommendation made by the Canadian Section committee.

**Willard F. Rockwell Jr.**, president of Rockwell Mfg. Co., Pittsburgh, has been elected president of the Gas Appliance Manufacturers Assn.—the first time in the organization's history that this office has been held by both a father and his son. Mr. Rockwell was also recently chosen president of the Pennsylvania Chamber of Commerce.

(Continued on page 38 P&R)



**OMAHA CHOOSES  
INFILCO EQUIPMENT**  
*for*  
**WORLD'S LARGEST**  
high-rate water treating plant

...saves hundreds of thousands  
...doubles production in half the  
space with latest ACCELATOR®  
clarifying units.

Consulting Engineers:

**BURNS & McDONNELL ENGINEERING CO.**

Kansas City, Mo.

Now another important city has turned to INFILCO high-rate water-treating equipment because of the advantages it provides. The plant will be the largest of its kind in the world, with a capacity of 140,000,000 gallons per day.

The Metropolitan Utilities District of Omaha needed to greatly increase production of high quality water from the Missouri River, in limited space at minimum cost. Extensive studies proved that "ACCELATOR" clarifiers were the best answer.

Over 1900 "ACCELATOR" treating plants are now producing results like these—results you, too, can expect from INFILCO's advanced engineering and equipment.

INFILCO KNOWS HOW! Write for copy of Bulletin No. 1825-1.

*Inquiries also invited on coagulation, precipitation, sedimentation, filtration, flotation, aeration, ion exchange and biological processes.*



**INFILCO INC.**  
Tucson, Arizona

*The ONE company  
offering equipment  
for ALL types of water  
and waste treatment.*



5542

Offices in principal cities in North America

(Continued from page 36 P&amp;R)

**Johns-Manville's** reorganization of its Industrial Products Div., which went completely into effect on Jan. 1, now gives the company a total of nine operating divisions. As previously announced, the Industrial Products Div. has been split into a Pipe Div., a Packings & Friction Materials Div., and an Industrial Insulations Div. Heading the group as vice-president for industrial products divisions is John A. O'Brien, a senior vice-president of

The latter two are also vice-presidents of Johns-Manville Sales Corp., while Mr. Turnbull is a vice-president of Johns-Manville Products Corp. Mr. Orth, an AWWA director and a member of the WSWMA board of governors, has been with Johns-Manville since 1924, when he joined the firm as an acoustical engineer.

It was also announced recently that Edward C. Koch, formerly manager of dealer sales for the Transite Pipe Dept., has been appointed manager of the Johns-Manville Market Surveys Dept., succeeding Edward A. Phoenix, who met a tragic death during last October's flood.



R. F. Orth



T. R. Turnbull



G. R. R. Wahl



J. H. Goodwin

Johns-Manville Corp., who was formerly general manager of the Industrial Products Div.

General manager of the new Pipe Div. is Robert F. Orth, who has been manager of the Transite Pipe Dept. since 1946 and is a vice-president of Johns-Manville Sales Corp. Mr. Orth's staff includes T. R. Turnbull, production manager; George R. R. Wahl, merchandise manager; and John H. Goodwin, general sales manager.

**Water, water everywhere**, but not in the cuspidor—except, of course, when it's in use! That's a new Navy order, which is expected to save \$160,000 in water bills each year by reducing the consumption in Navy dental departments from 250 mil gal to a mere 4.6535 mil gal per annum. Military secret involved is a special valve designed by Cmdr. William N. Gallagher of the Naval Dental School at Washington to operate dental disposals only when there are cusps to idor. Even if this saving isn't noticeable in the tax bite next year, it is certainly a drop in the right bucket.

**H. E. Hudson Jr.** has become associated with Hazen & Sawyer, Engrs., New York. He had been chief engineer of the Illinois State Water Survey since 1946, and previously had held the position of filtration engineer at Chicago's South Dist. Plant. Chairman of AWWA's Committee on Water Use, Mr. Hudson is also a member of the National Research Council subcommittee on water supply and of the EJC Board of Review on National Water Policy.

(Continued on page 40 P&amp;R)



## Huge WHEELER-ECONOMY AXIAL FLOW PUMPS

Designed to Establish a Syphon  
in Pioneer Application  
at Donaldsonville, La.

To establish water supply from the Mississippi River to the vast area of Bayou La Fourche, required the utmost ingenuity and cooperation between the State of Louisiana engineers and Economy Pumps engineers. Three 42" x 48" Wheeler-Economy AFV Axial Flow Pumps were selected to do the job. Design capacity is 45,000 GPM at 17' TDH. But when these pumps operate as a syphon they move 65,000 GPM. Motors are 250 HP operating at 514 RPM. Pumps in operation run 24 hours a day.

It is believed this is the first application of pumps of this design to pass such a high volume of water on the syphon principle. Infinite care in planning and construction is typified by the exact length each pump had to meet—51' 3/4" from underside of mounting plate to end of suction bell. Moreover, every increment assembled in the field had to be made airtight by skilled Wheeler-Economy specialists to make possible the necessary vacuum.

Success was largely assured by Wheeler-Economy's extensive manufacturing facilities in Philadelphia. Here, in one of the largest test pits in the industry, witness tests were made by the State of Louisiana and the contractor to prove pump performance before delivery.

You, too, can rely on Wheeler-Economy for help on complex pumping problems, dependable delivery and performance that lives up to promise.

WEE13

## WHEELER-ECONOMY PUMPS

ECONOMY PUMPS, INC. • DIVISION OF E. H. WHEELER MANUFACTURING CO.  
19TH AND LEHIGH, PHILADELPHIA 32, PA.



(Continued from page 38 P&amp;R)

**Got pot wot?**—alum pot wot's what we mean. If you do, by all means rush it off to Jack Hinman at Box 389, Iowa City, Iowa. Jack—the "I away" of Iowa—is back home for the moment "between engagements." Anything but unoccupied, though, he has now channeled his boundless enthusiasm and energy into seeking out more facts on the early history of rapid sand filtration, and, particularly, the who and when and what of the early alum pot (see letter, P&R, p. 48). Whatever the source, any dope on its origins will sweeten the pot for Jack.

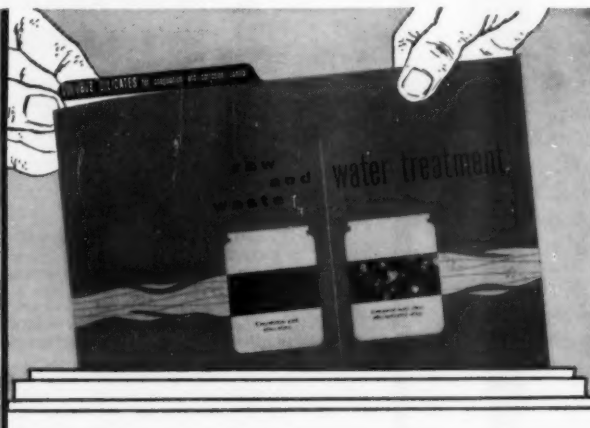
**Metropolitan Chicago's** growing water needs have been the subject of a comprehensive engineering study made for the city by the firm of Alvord, Burdick & Howson. In general, the

consultants recommended a stepped-up improvement plan for the present Chicago service area, involving an expenditure of more than \$250,000,000 by 1980. An additional \$26,500,000 in capital improvements and \$15,000,000 in express transmission mains and booster stations are estimated as necessary if Chicago is to meet the future demands of other communities in the metropolitan area. Some of the data on which this report was based appeared in L. R. Howson's article in the November 1955 issue (p. 1030).

**Leo V. Garrity**, who recently resigned as assistant general manager and chief engineer of the Detroit Dept. of Water Supply, has joined the consulting engineer firm of Hubbell, Roth & Clark, Detroit.

(Continued on page 42 P&amp;R)

## data file on treating raw and waste waters with Activated Silica Sols



- Request on your plant stationery, useful bulletins and reprints discussing the advantages of activated

silica sols as coagulating aids, how to prepare these sols, information on the N-Sol Patented Processes.

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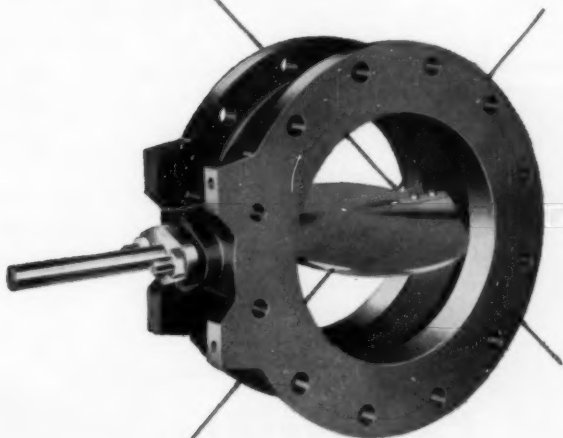


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for preparing activated silica sols  
from N silicate are licensed with-  
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service...specify  
AWWA standard  
butterfly  
valves...**



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METERS  
FEEDERS  
CONTROLS

(Continued from page 40 P&amp;R)

A lie detector, rather than a leak detector, was what finally permitted town authorities of Dalzell, Ill., to bring a halt to losses of 25,000 gal per week from their water reservoir last month. Inasmuch as the losses were significant enough to put the 500-population community on short rations during the leak detector stage, it definitely put it in short temper when that failed to disclose any break in the system. When just the threat of subjecting suspects to the lie detector proved enough to stop the loss, however, the sheriff apparently decided that enough well was well enough and suspended his investigation, leaving us and a whole nation, alerted by the United Press, to wonder not only whodunit, but where he stashed his haul. Ah well, it is sort of satisfying to suppose that water is worth stealing.

Robert P. Young has been named manager of the New York district office of Peerless Pump Div., Food Machinery & Chemical Corp. Associated with Peerless since 1948, he succeeds F. W. McCann, who has resigned.

Roger Higgins has accepted a position as city engineer and superintendent of water and sewage at Maryville, Mo. He had been Hannibal, Mo., city chemist since 1942.

H. M. Appleton has been appointed assistant plant manager of The Permutit Co. manufacturing division at Lancaster, Pa. H. Plymire becomes plant superintendent.

B-I-F Texas, southwestern division of B-I-F Industries, has moved its Houston office to 2435 North Boulevard.

(Continued on page 44 P&amp;R)



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I'm Cast Iron Pipe and I'm designed to perform rugged service for many, many years. I can take it for centuries at a time and still be in tip top shape, and the best recommendation I have is my past performance. Check my record . . . Efficient and economical service for hundreds of years . . . I'm a rugged individual ready to serve.

Alabama's Super De Lavaud Cast Iron Pipe . . . sizes of 3" to 24" in modern long lengths . . . Bell and Spigot, Roll-on-Joint, and Mechanical Joint and flanged.

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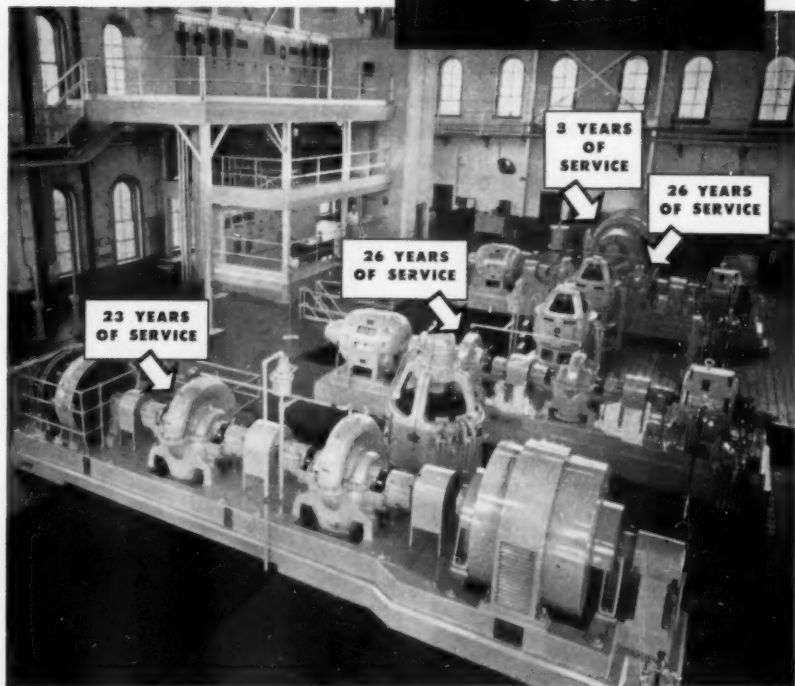
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*Nashville goes  
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**CENTRIFUGAL**  
**PUMPS**



The years of service shown on these De Laval centrifugal pumps tell their own story of dependability and progress. By revising its facilities, the George Reyer pumping station in Nashville has boosted its pumping capacity to 100 million gallons per day. The De Laval pumps, which have been in service for years, play an integral part in this more efficient

operation. The newest De Laval unit handles 40 million gallons per day.

In fact 80% of all cities in the United States, with a population of 100,000 or over, use De Laval centrifugal pumps. Capacities of De Laval centrifugal water works pumps range from 100 thousand to 100 million gallons per day. Write for your copy of new De Laval Bulletin 1004.



**DE LAVAL** *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY  
822 Nottingham Way, Trenton 2, New Jersey

(Continued from page 42 P&amp;R)

**Fred S. Childs**, of Bogert & Childs, Cons. Engrs., New York, has been elected president of the New Jersey Board of Professional Engineers & Land Surveyors. Mr. Childs is now serving his third term in this office.

**Arnold A. Brusch** is retiring as superintendent of the Montclair, N.J., Water Bureau at the expiration of his terminal leave. Mr. Brusch has held his present post since 1953, having joined the municipal staff in 1926.

**Simplex Valve & Meter Co.** has moved its New York City offices to 117 Liberty St. George L. Walker continues as district manager. In addition to sales, the office will also schedule and service equipment in the metropolitan area.

**With Water Wagon Month** at hand and S-D Day just passed, this should be the propitious moment to report that at least one insurance company offers lower rates to motorists who sign an oath to drink no alcoholic liquors. Actually, of course, with water considerably lower in price than any alcoholic beverage we've been able to find, the provision affords the teetotaling motorist an opportunity to save two ways.

Unfortunately for our pocketbook, we're not the swearing type. Were we, though, we might well be tempted just this once to wish for "the good old days," when, according to the *Cape Cod Guide*, insurance company stipulations were against "those who risked their health by drinking water."

Anyway, we ought to conserve water.

(Continued on page 80 P&amp;R)



**6 Reasons why  
PALMER SURFACE  
WASH SYSTEMS  
are specified by  
water works engineers**

1. Prevent Sand Beds From Cracking.
2. Eliminate Mud Balls.
3. Save Wash Water.
4. Lengthen Filter Runs.
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**BELL JOINT  
LEAK CLAMPS  
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COMPOUND  
C-I-60 CAST  
IRON BOLTS**

Carson glands and bolts made of corrosion-resistant C-I-60 cast iron—last as long as cast iron pipe. Glands accommodate variations in pipe dimensions, insure uniform compression of rubber gasket.

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## MECHANICAL JOINTS

...another plus feature  
available with

## VALVES AND HYDRANTS

**D**ARLING mechanical joint valves and hydrants are built to approved standards and provide all the recognized advantages—such as simple, fast installation with no special skills required... and assurance of tight joints.

But whether or not you require mechanical joints, don't forget the outstanding *performance* advantages that only Darling Valves and Hydrants can give

you. For example, there's Darling's revolutionary B-50-B packless dry-top hydrant development with its ball-bearing operation and "O" ring seals. And in gate valves, Darling's fully revolving double disc, parallel seat principle... for long life, low maintenance and unmatched operating ease.

Be sure to get *all* the facts. Complete information is yours for the asking.

Darling B-50-B  
Fire Hydrant with  
mechanical joint.

Darling Revolving  
Disc Gate Valve with  
mechanical joints.



**DARLING VALVE & MANUFACTURING CO.**

Williamsport 23, Pa.

*Manufactured in Canada by The Canada Valve & Hydrant Co., Ltd., Brantford 7, Ont.*



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**96%**

OF ALL 6-INCH AND LARGER CAST IRON WATER MAINS EVER LAID IN 25 REPRESENTATIVE CITIES ARE STILL IN SERVICE.

Based on the findings of a survey conducted by leading water works engineers.

# CAST IRON PIPE

# DISTINGUISHED CLUB...

The **Cast Iron Pipe Century Club** is probably the most unusual club in the world. Membership is limited to municipal, or privately-owned, water and gas supply systems having cast iron mains in service for a century or more. Although the Club is formally constituted, there are no dues, no regular meetings, and no obligations other than to inform the Recording Secretary if and when the qualifying water or gas main is taken out of service, or, sold for re-use.

In spite of the unique requirements for membership,

the Club roster grows, year by year, from 18 in 1947 to 73 in 1955. Members comprise 38 *water* and 35 *gas* utilities, in cities large and small, from the Pacific to the Atlantic, from Canada to the Gulf.

If your records show a cast iron main in service, laid a century or more ago, the Club invites you to send for a handsome framed Certificate of Honorary Membership. Address Thomas F. Wolfe, Recording Secretary, Cast Iron Pipe Century Club, Peoples Gas Bldg., Chicago 3, Illinois.

## C. I. P. CENTURY CLUB NOW HAS 73 MEMBERS!

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Department of Water and Water Supply  
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BALTIMORE, Maryland  
Bureau of Water, Dept. of Public Works  
BALTIMORE, Maryland  
Consolidated Gas Electric Light and Power Co.  
BOSTON, Massachusetts  
Public Works Dept., Water Division  
BOSTON, Massachusetts  
Boston Consolidated Gas Co.  
BOUND BROOK, New Jersey  
Public Service Electric & Gas Co.  
BRIDGEPORT, Connecticut  
Bridgeport Gas Light Company  
BUFFALO, New York  
Department of Public Works, Division of Water  
CHARLESTON, South Carolina  
South Carolina Electric & Gas Co.  
CHICAGO, Illinois  
Peoples Gas Light & Coke Company  
CHICAGO, Illinois  
Water Works Department  
CINCINNATI, Ohio  
Cincinnati Gas & Electric Co.  
COLUMBIA, Pennsylvania  
Columbia Water Company  
DETROIT, Michigan  
Board of Water Commissioners  
DETROIT, Michigan  
Michigan Consolidated Gas Co.  
\*EVANSVILLE, Indiana  
Southern Indiana Gas & Electric Company  
FALL RIVER, Massachusetts  
Fall River Gas Works Company  
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City of Frederick Water Dept.  
FREDERICK, Maryland  
Frederick Gas Company, Inc.  
CITY OF FREDERICKSBURG, Virginia  
Gas Department  
HALIFAX, Nova Scotia  
Public Service Commission, Public Water Supply  
HARTFORD, Connecticut  
The Hartford Gas Company  
HARTFORD, Connecticut  
Water Bureau of the Metropolitan District  
HUNTSVILLE, Alabama  
Municipal Water Works  
INDIANAPOLIS, Indiana  
Citizens Gas & Coke Utility  
LANCASTER, Pennsylvania  
Bureau of Water  
LOUISVILLE, Kentucky  
Louisville Gas & Electric Co.  
LYNCHBURG, Virginia  
City of Lynchburg Water Department  
MADISON, Indiana  
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New Haven Gas Company  
NEW ORLEANS, Louisiana  
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HOBOKEN, New Jersey  
Philadelphia Electric Co., Gas Dept.  
PAINESVILLE, Ohio  
City of Painesville, Gas District Department  
\*PEORIA, Illinois  
Central Illinois Light Company  
PHILADELPHIA, Pennsylvania  
Department of Public Works, Bureau of Water  
PHILADELPHIA, Pennsylvania  
Philadelphia Gas Works Co.  
PITTSBURGH, Pennsylvania  
Bureau of Water, Department of Public Works  
PLYMOUTH, Massachusetts  
Plymouth Gas Light Company  
POTTSVILLE, Pennsylvania  
Pottsville Water Company  
PROVIDENCE, Rhode Island  
Providence Gas Company  
QUEBEC, Canada  
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RICHMOND, Virginia  
Department of Public Utilities (Water)  
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Division of Water & Sewers  
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North Shore Gas Company  
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Water Division, Department of Engineering  
TODD, Ontario  
The Consumers' Gas Co. of Toronto  
TROT, New York  
Department of Public Works  
UTICA, New York  
City of Utica, Board of Water Supply  
WHEELING, West Virginia  
City of Wheeling Water Department  
WILMINGTON, Delaware  
Wilmington Water Department  
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Water Department

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During 1954 more Leopold duplex filter bottoms were sold than in any previous year in our history. To date, there are well over 300 plants (with a daily capacity in excess of 1 1/4 billion gallons) that have selected Leopold bottoms—including such major municipal installations as Phoenix, Arizona; Houston, Texas; Trenton, New Jersey; Detroit, Michigan; Baltimore, Maryland; Columbus, Ohio; Kansas City, Missouri; Omaha, Nebraska; and Philadelphia, Pennsylvania. Represented in this group are the five largest municipal filter plants under construction in the country at this time.

- Dry Chemical Feeders • Mixing Equipment
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2413 W. Carson Street  
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## Correspondence



### Revision Revision

*To the Editor:*

There is a little statement in the revision of Chapter 8 of *Water Quality and Treatment* (August 1955 JOURNAL, p. 769) which I believe is incorrect. It is that, from the very beginning of the use of coagulants, it was realized that the chemicals should be uniformly distributed throughout the water. It may have been realized, but it certainly was not always provided for in a suitable way.

I remember a number of plants—the old Springfield, Mo., plant was one—in which the raw-water alum and lime all fell out of individual pipes in one corner of the basin and mixed as well as they could. So I have set out to straighten out my thoughts on the early application of coagulants in rapid sand filtration practice. For some reason I have had it in my mind that Albert R. Leeds, of Stevens Institute, Hoboken, N.J., had a hand in the development of Isaiah Smith Hyatt's Patent No. 293,740 of Feb. 19, 1884. This was for the application of alum to the water just before it went onto the filter. And it confused the application of coagulants until it expired in 1901. M. N. Baker (*The Quest for Pure Water*, p. 183) mentions Col. L. H. Gardner, former superintendent of water works in New Orleans, as having something to do with the matter. Now I have found an article by Gardner in the old *Scientific American* supplement for 1885, in which he tells about the incident. It seems that

(Continued on page 50 P&R)

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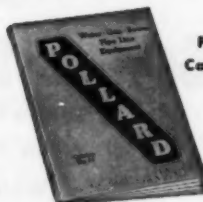
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**Correspondence***(Continued from page 48 P&R)*

Gardner was interested in coagulants, particularly iron coagulants, and that he actually clarified the water of St. Louis satisfactorily as a demonstration in 1884. But nobody seems to have paid any attention to it. He was working on coagulants in New Orleans in 1883 when Isaiah Smith Hyatt brought one of his filters down to New Orleans to demonstrate it. He ridiculed Gardner's work. But his filter without coagulants did not clarify the Mississippi River water. Gardner persuaded him to add a little alum to the water going on the filter and Hyatt got a satisfactory result. He went home and took out a patent. An amusing sequel is that, when the American filters were later installed in New Orleans, in 1892-93, they used the direct application of coagulants to the filter without basin treatment, and the plant was a failure. And it took the work of George W.

Fuller at Louisville from 1895 to 1897, plus some later activity, to point out that the important thing in rapid sand filtration is the preparation of water for the filter. Some people do not recognize it yet.

One of the things that I want to know about now is the early history of the alum pot. I have hunted for it in *The Quest* unsuccessfully.

JACK J. HINMAN JR.

Iowa City, Iowa

Sep. 26, 1955

*Can anyone give Jack the scoop on the pot?—Ed.*

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*To the Editor:*

I should like to call to your attention an incident which was apparently overlooked in your highly instructive disserta-

*(Continued on page 52 P&R)*



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In addition, tenderers are invited to submit quotations for the manufacture and supply only of the Pipes and Specials for Stage 3 of the City's Water Augmentation Scheme.

The estimated requirements under Stage 3 are as follows:—

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The Contract Documents and Drawings are available for inspection by prospective Tenderers at the office of the City and Water Engineer during normal office hours.

Two copies of the Documents and half-scale prints of the Drawings will be supplied to prospective Tenderers on payment of a deposit of Two Hundred Pounds (£200), which amount will be refunded to *bona fide* Tenderers on receipt of one copy of the Documents properly completed and duly signed by the Tenderer.

Extra copies of the Documents and half-scale prints of the Drawings will be supplied, at the discretion of the Engineer, on a payment of Twenty-five Pounds (£25) per copy, which sum will not be refunded.

Tenders accompanied by a cheque for One Thousand Pounds (£1,000) marked for payment by a Bank and valid for six (6) months, shall be delivered to the Town Clerk, City Hall, Port Elizabeth, South Africa, not later than 12.45 p.m. on the 15th March, 1956, on which date they will be opened in public in No. 1 Committee Room, City Hall, at 2.15 p.m.

The Council does not bind itself to accept the lowest or any tender.

Municipal Notice No. 432, 11th November, 1955. (0241/070).

G. H. BREWER, TOWN CLERK.

## Correspondence

(Continued from page 50 P&R)

tion on "Pink" in the October 1955 JOURNAL (p. 46 P&R). The London Metropolitan Water Board, in its 35th report, mentions the receipt of customers' complaints to the effect that their underwear had turned pink on washing. Subsequent investigation by the board showed that the color was due to the action of alkaline washing water on phenolphthalein, an ingredient in laxatives taken by the wearers of the garments. Consequently, it would appear that "pinkicization" in the lavatory need not be limited to the facilities mentioned in your October article.

R. C. M. CROSSLEY

*Stow-on-the-Wold*  
*Gloucestershire, England*  
*Nov. 17, 1955*

For ignoring a matter that touches the very foundations of the Empire, our faces would indeed be pink, except that an abstract of the report referred to appeared in the November 1955 issue (*Condensation*, p. 76 P&R).—Ed.

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Open *with* the pressure for faster water delivery.

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Assure positive drainage.

Are available for any type of connection.

All working parts removable through top—no digging or special tools required.

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## Condensation

**Key:** In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is pagged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH*—*Bulletin of Hygiene (Great Britain)*; *CA*—*Chemical Abstracts*; *Corr.*—*Corrosion*; *IM*—*Institute of Metals (Great Britain)*; *PHEA*—*Public Health Engineering Abstracts*; *SIW*—*Sewage and Industrial Wastes*; *WPA*—*Water Pollution Abstracts (Great Britain)*.

### CHEMICAL ANALYSIS

**Determination of Low Alkalinity or Acidity in Water.** T. E. LARSON & L. HENLEY. *Anal. Chem.*, 27:851 ('55). App. consisted of Beckman Model G glass-electrode pH meter, magnetic stirrer, air diffuser, 5-ml microburet with Pt capillary tube, and water bath at  $25^{\circ} \pm 1^{\circ}$ . Method is based on principle that increments of added acidity (after neutralization) increase H ion concn. as linear function. Extrapolation to  $1 \times 10^{-7}$  mole ( $H^+$ )/l provides precise equiv. endpoint. The procedure is sensitive and accurate to 0.05 ppm (as  $CaCO_3$ ) when titrating

200-ml sample of  $-1$  to  $+1$  ppm alk. with  $0.02N H_2SO_4$ —*CA*

**Determination of Alkalinity and Total Cations in Water.** B. A. SARD & J. UNGAR. *Chemistry & Industry (Br.)*, p. 699 ('55). Alky. in  $H_2O$  present as  $NaHCO_3$ , expressed in ppm as  $CaCO_3$ , was detd. by titrating 100-ml aliquots against 0.10 or 0.020N HCl or  $HNO_3$  by using screened methyl orange (I), neutral pH of 3.8, as indicator. Titration of similar aliquots of same sample to endpoint by using I and pH meter gave identical results, whereas values obtained by titration to pH 4.5, as suggested by Navone,

(Continued on page 64 P&R)

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**AMERICAN CONCRETE  
PRESSURE PIPE  
ASSOCIATION**

228 North LaSalle Street  
Chicago 1, Illinois



(Continued from page 62 P&R)

differed considerably.  $H_2O$  contg. dissolved ionized solids was passed through column of Permutit "Zeo-Karb" 225-H cation-exchange resin (14/52 B.S. mesh) (II), and equiv. mineral acidity (ema) measured by titration with 0.10 or 0.020N NaOH. Values obtained by use of I as indicator were more accurate than those obtained by titration to pH 4.5 for detn. of ema. Comparison of column and mech.-rotation shaking technique for eff. in terms of ema was made by using II. Although quants. of resin, contact time, and aliquots were varied within reasonable limits, static equil. was set up and cation exchange was incomplete by using mech.-rotation shaking technique as compared to column method. 25-30-cm-tall column of II in 14-16-mm diam. chromatographic tube can be used to analyze solns. for total cation concn. without diln. if total cation concn. does not exceed 5,000 ppm in terms of  $CaCO_3$ . Total cation concn. can be detd. by adding total alky. to ema obtained by use of I. Na concn. can be calcd. by subtracting total hardness detd. by versenate

method of Betz and Noll for total cations. —CA

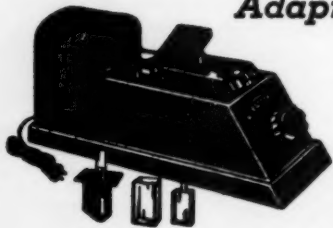
**Determination of Hardness of Water.** H. MUTO, T. NARIUE & Y. SAITO. J. Soc. Brewing (Japan), 49:409 ('54). Schwarzenbach's method was compared with gravimetric and soap methods. Mn (0.4 mg/l) accelerated decoloration of indicator, and blue color did not appear at end of titration. Fe had same effects as Mn, and red color persisted up to end of titration in presence of 1 mg/l Fe. Effect of Al was weaker than that of Mn and Fe; presence of 1.6 mg/l Al gave slight red color at end of titration. Presence of these ions gave results that were too high. Interference by these ions was elimd. by addn. of KCN and hydroxylamine-HCl.—CA

**The Determination of Small Amounts of Oxygen Dissolved in the Waters of Boilers of High and Medium Pressure.** A. BERGER, J. PIROTTE & E. LECLERC. Bull.

(Continued on page 66 P&R)

## KLETT SUMMERSON ELECTRIC PHOTOMETER

*Adaptable for Use in Water  
Analysis*



Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

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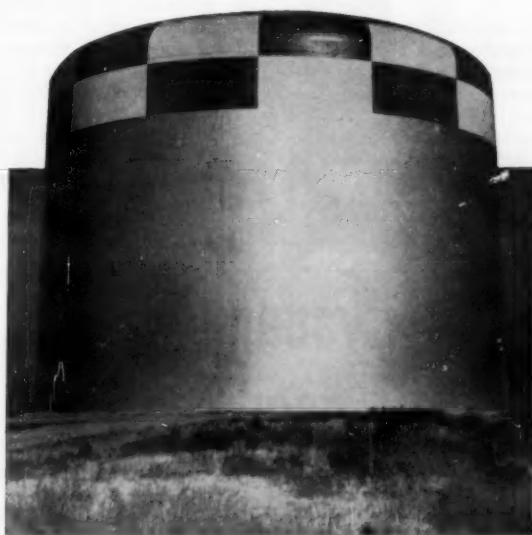
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(Continued from page 64 P&amp;R)

Centre Belge Etude et Document Eaux (Belgium), No. 27, p. 30 ('55). 2 modifications of Winkler method are given in order to increase sensitivity of O detn. 1st involves spectrophotometric detn. of  $I_3^-$  at 350 m $\mu$  with substitution of  $MnSO_4$  for  $MnCl_2$  and  $H_2PO_4$  for  $HCl$  in order to elim. formation of  $ICl_2^-$ . Precision of 0.5  $\gamma/l$  is attained. Alternate method utilizes color intensity developed when oxidation-reduction reagent o-tolidine is added to basic hypochlorite soln. Readings are made at 435 m $\mu$ . Latter method suffers from interference of org. materials which may be present in boiler waters.—CA

**Determination of Substances in Minute Quantity. X. Colorimetric Determination of Sodium in Water.** T. KATO, Y. OKINAKA & T. NOMURA. Technol. Rpts. Tohoku Univ. (Japan), 19:81 ('54). Method was worked out whereby Na pptd. as  $NaMg-(UO_2)_2(AcO)_6$  could be detd. in concn. of 30–150  $\gamma$  of Na per ml of test soln. Mg was detd. colorimetrically by using Titan

Yellow. K salts interfered with tests. Method was applied to river water, and accuracy of method was shown to be better than 98.5% by adding known amts. of NaCl to river samples.—CA

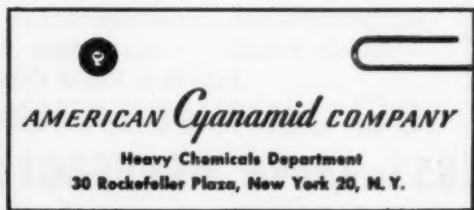
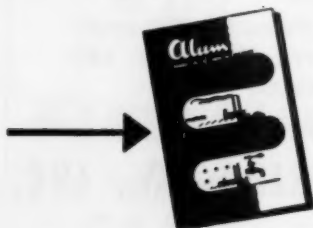
**New Colorimetric Determination With Thiocyanate.** S. UTSUMI. J. Chem. Soc. Japan, 74:32 ('53). *IV. Iodide and Cyanide.* In detn. of iodide and cyanide, mercuric thiocyanate is added to sample and mercuric iodide or cyanide is formed. Liberated thiocyanate is detd. colorimetrically with ferric alum and concn. of iodide or cyanide is then obtained by calcn. *V. Bromide or Iodide in the Presence of Chloride.* To determine bromide or iodide in presence of chloride, 10 mg solid silver thiocyanate, 1 ml ethyl alcohol, and 2 ml ferric alum soln. are added to 10 ml sample. Thiocyanate liberated is detd. colorimetrically from orange color formed with ferric ions, and concn. of bromide or iodide is obtained by calcn. Chloride in concns. of less than 20 mg/l does not interfere.—WPA

(Continued on page 68 P&amp;R)

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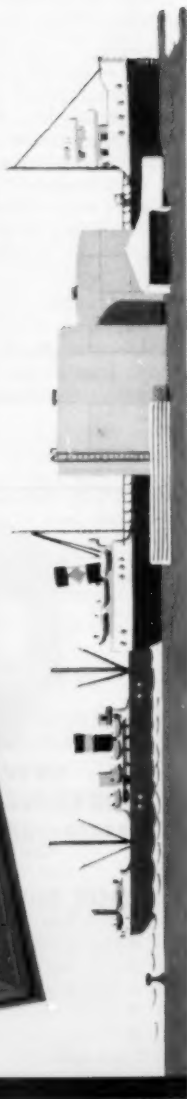
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(Continued from page 66 P&amp;R)

## HEALTH AND HYGIENE

### Effect of Fluoride in Drinking Water.

H. B. McCauley & F. J. McClure. Pub. Health Rpts., 69:671 ('54). Exposure to fluoride in drinking water was studied for evidence of detrimental effects on skeletal calcification and bone development in children. 3 groups of children, aged 7-14 yr, living in Lubbock and Amarillo, Tex., and Cumberland, Md., were selected on basis of continuous exposure to their communal drinking waters, which contained fluoride in amts. of 3.5-4.5 ppm F, 3.3-6.2 ppm F, and 0.1 ppm F, resp. Radiographs were taken of right hand and wrist of 2,050 children. From these x-rays, skeletal age was assessed and quant. index of ossification detd. No evidence available from radiographs was obtained which would indicate that there was any adverse effect on carpal bones or on their growth and development as consequence of continuous use of drinking water

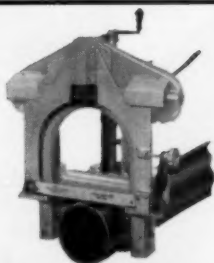
contg. approx. 3.5-6.2 ppm F. These results confirm safety of maintg. fluoride level of public water supplies at about 1.00 ppm F, by controlled fluoridation, for reduction of tooth decay.—CA

### The Incidence of Nitrates in Rural Ontario Well Waters.

R. A. Johnston. Can. J. Public Health, 46:30 (Jan. '55). Cases of methemoglobinemia in infants, associated with high nitrate levels in water supply, are apparently widespread in United States and Canada, and reports on this subject have also come from Belgium and England. Paper describes results of survey of 484 well waters of Ontario in which nitrate content and bact. condition were detd. It was evident from these examns. that some of these well waters (about 14%) contained more than 10 ppm nitrate-nitrogen which has been suggested as max. level for safety. High nitrate levels were commoner in dug wells than in drilled wells. Seasonal fluctuations in nitrate levels were found to be considerable. High percentage of nitrate-contg. waters showed no evidence of poln. from human or animal sources, finding which has been noted elsewhere and may be caused by seasonal leaching of topsoil, vegetation, or nitrate deposits.—BH

### Methemoglobinemia Due to Nitrates and Nitrites in Drinking Water.

H. T. Fawns & A. G. V. Aldridge. Brit. Med. J., p. 575 (Sep. 4, '54). Account of case of methemoglobinemia due to nitrates and nitrites occurring in infant aged 5 wk who, after 4 wk of breast feeding, was put on dried-milk feed diluted with well water. Child became feverish and cyanosed, and blood anal. showed presence of methemoglobin in amt. of 56.8% of total pigment. Anals. of well water gave figures of 0.8 ppm nitrate and 0.002 ppm nitrite. Child became perfectly well in hospital, and ascorbic acid in daily total dose of 1,000 mg for 3 days appeared to be very effective treatment. After discharge, child relapsed as result of use of another well water contg. 0.35 ppm nitrate, but recovered on ascorbic acid and substitution of city water from local supply. Level of methemoglobin in blood of mother and 2 other children, all of whom remained well, was found to be well above normal range.—BH



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## Section Meetings

**Michigan Section:** The seventeenth annual meeting of the Michigan Section was held at the Durant Hotel, Flint, on Sep. 14-16, 1955. Flint and the surrounding cities went all out to provide a very well planned meeting. Total registration was 315, with 79 ladies in attendance.

Wednesday was devoted to opening the conference and giving special attention to the new water facilities in Flint. Four papers, presented by Herschel O. Self, Louis E. Ayres, Stuart Maynard, and Raymond Harwood, covered the history,

expansion program, design features, and operating experiences at the Flint Water Treatment Plant. It is interesting to note that a room large enough for the meeting was available at the new filtration plant. Inspection trips were made through the treatment plant and to the new dam constructed on the Flint River and named after the late Earl Holloway, a former Section chairman. Of particular interest was the great flexibility of this new softening and filtration plant, enabling it to treat water of varying quality.

(Continued on page 72 P&R)

## Limitorque<sup>®</sup> VALVE OPERATORS



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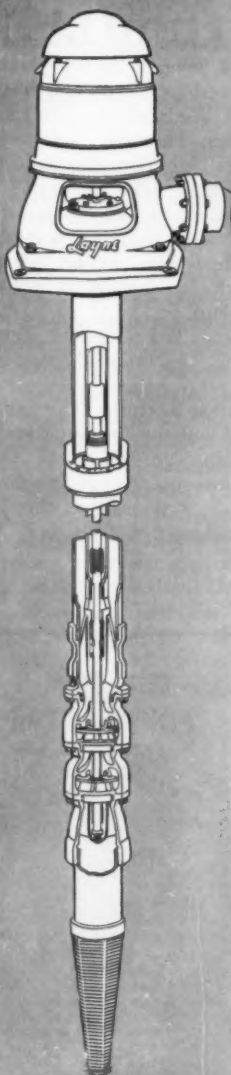
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**Section Meetings***(Continued from page 70 P&R)*

The annual presentation of news from the field was made by John E. Vogt, sanitary engineer with the Michigan Dept. of Health. He emphasized the unprecedented demands being placed on Michigan water supplies and the need for planning and solving some of these problems on an area basis.

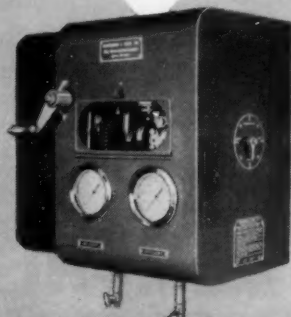
A complete list of the papers presented at the technical sessions will be found in the December 1955 JOURNAL (p. 1233).

At the banquet on Thursday evening greetings were presented by Albert E. Heustis, commissioner, Michigan Dept. of Health. Fifty members received the Edward Dunbar Rich Award for 25 years of meritorious and faithful service in providing and maintaining a safe and adequate water supply. T. L. Vander Velde was nominated to receive the Fuller Award.

The manufacturers' representatives and the Water and Sewage Works Manufacturers Assn. were very gracious hosts at a smoker on Wednesday night and a cocktail hour on Thursday. A very interesting ladies' program entertained the wives during their stay in Flint. The city, with its tremendous industrial expansion, had many items of interest for all those in attendance. Friday afternoon afforded time for an inspection of a General Motors plant.

T. L. VANDER VELDE  
*Secretary-Treasurer*

**North Central Section:** The 39th annual convention of the former Minnesota Section, now the North Central Section (including Minnesota, North Dakota, and South Dakota), was held at the Hotel Radisson, Minneapolis, Oct. 5-7, 1955.

*(Continued on page 74 P&R)*

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**Section Meetings***(Continued from page 72 P&R)*

The meeting was well attended and a well rounded and instructive program of papers was provided. (A list of the papers and their authors appeared in the December 1955 JOURNAL, p. 1235.)

The luncheon and business meeting of the Section was held Thursday noon, Oct. 6, at which time all committee chairmen and officers made their annual reports to the membership. The following new officers were elected: Chairman—L. H. Coult, Fairmont, Minn.; vice-chairman—H. H. Behlmer, Fargo, N.D.; trustees—Clayton M. Bach, Minneapolis, and Wil-lard J. Bell, St. Paul. M. D. Lubratovich, Duluth, and A. T. Hanson, Sioux Falls, S.D., continued as trustees.

At the annual banquet held Friday evening, an exceptionally good program of entertainment was preceded by the pres-

entation of the Past-Chairman's Pin to Howard J. Sowden, Fergus Falls, Minn. The Finch Award went to Ira M. Vraalstad, St. Louis Park, Minn., and the Fuller Award to William Yegen, Bismarck, N.D., for outstanding services to the Section. During the convention the Board of Trustees held two meetings.

LEONARD N. THOMPSON  
*Secretary-Treasurer*

**Ohio Section:** The Ohio Section held its seventeenth annual conference in the Neil House Hotel, Columbus, on Sep. 21-23, 1955. Registration was 251, considerably less than in the previous year. Forty-one ladies attended.

Chairman George J. Van Dorp officially opened the conference, Wednesday after-

*(Continued on page 78 P&R)*

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Capacities 5,000 to 2,000,000 gallons—with hemispherical, ellipsoidal or conical bottoms. Also flat-bottom tanks for stand-pipe storage. Correctly built in accordance with AWWA specifications.

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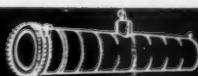


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**EQUIPMENT.** Permutit supplies complete equipment. Critical parts such as valves, chemical feeders and controls are designed and made by Permutit.

5

Growing U. S. cities and towns are faced with using lower-grade water. Results: increased hardness, turbidity, iron, high CO<sub>2</sub> "aggressive waters", other problems . . . complaints from homeowners, businesses, industries.

- **For expert answers** more and more waterworks officials and their consultants are buying the complete service offered by leading water-conditioning firms. Here's how Permutit (rhymes with "compute it"), a pioneer and largest in the field, tackles a water problem:

- **Water analysis**, study of the problem and past experience provide data on possible methods of treatment. The process offering the best balance of initial and operating cost vs. desired quality of treated water is selected.

- **Complete proposal** by Permutit engineers covers type, size and capacity of equipment, price, any special engineering services and performance guarantees.

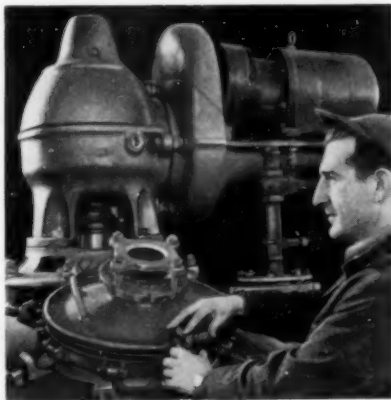
- **Manufacturing** — After the proposal is accepted, Permutit designs the entire project, schedules assembly and shipping. Critical parts, ion exchange resins, control panels are all made in Permutit plants. (No other U. S. firm makes all these components.)

- **Test runs** — Where required, Permutit checks the installation, supervises start-up and initial operation, trains permanent operating personnel.

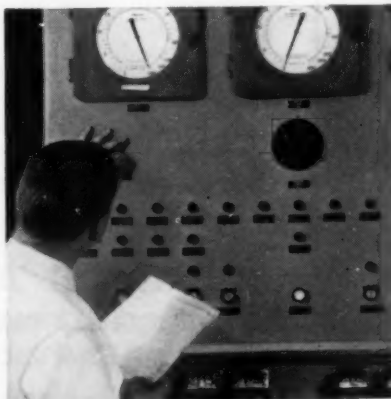
- **For further information** look up the Permutit office in your city or write to The Permutit Company, Dept. JA-1, 330 West 42nd St., New York 36, N. Y.



**WATER ANALYSIS.** Permutit's modern water-analysis laboratory tests over 1200 samples a month!



**ION EXCHANGE RESINS.** Permutit makes its own ion exchange resins, natural and synthetic zeolites.



**AUTOMATIC CONTROLS** to ensure optimum results are designed, assembled, wired and tested by Permutit.

**Section Meetings***(Continued from page 74 P&R)*

noon, Sep. 21, and then the mayor of Columbus, the Hon. Maynard E. (Jack) Sensenbrenner, officially welcomed the group. Don D. Heffelfinger, program chairman, and his committee provided a very interesting and well balanced program for those in the water works profession. (A list of the papers and the authors who presented them is given in the December 1955 JOURNAL, p. 1235.)

The annual banquet, held Thursday evening, was very well attended. Harry E. Jordan presented Wendell R. LaDue citations to Paul Harlamert, Cleveland; Maxfield Pease, Cleveland; E. P. Reep, Girard; Samuel Shenker, Columbus; and E. D. Smith, Lima. Tom Lathrop, Columbus, received a Life Membership Certificate, and John S. Gettrust, Kent, was nominated for the Fuller Award. Hamilton Robinson, of the College of Dentistry, Ohio State University, was the after-

dinner speaker, discussing the effects of toothpastes and fluorides on teeth.

The new officers elected for 1955-56 were: Donald D. Heffelfinger, Alliance—chairman; M. W. Tatlock, Dayton—vice-chairman; Pierce Bailey, Youngstown—trustee; and M. E. Druley, Wilmington—secretary-treasurer.

The ladies' program started Wednesday afternoon with a reception and tea. On Thursday there was a luncheon and a visit to the Westinghouse Mfg. Co. The manufacturers' cocktail hour that preceded the banquet was a most enjoyable mixer for the large group in attendance. Friday morning a description of the new Hoover Dam and Columbus' new 50-mgd Big Walnut Treatment Plant was given. The program was concluded Friday afternoon with a trip to the plant site for the formal dedication.

M. E. DRULEY  
*Secretary-Treasurer*

## WHY USE JOHNSON WELL SCREENS?

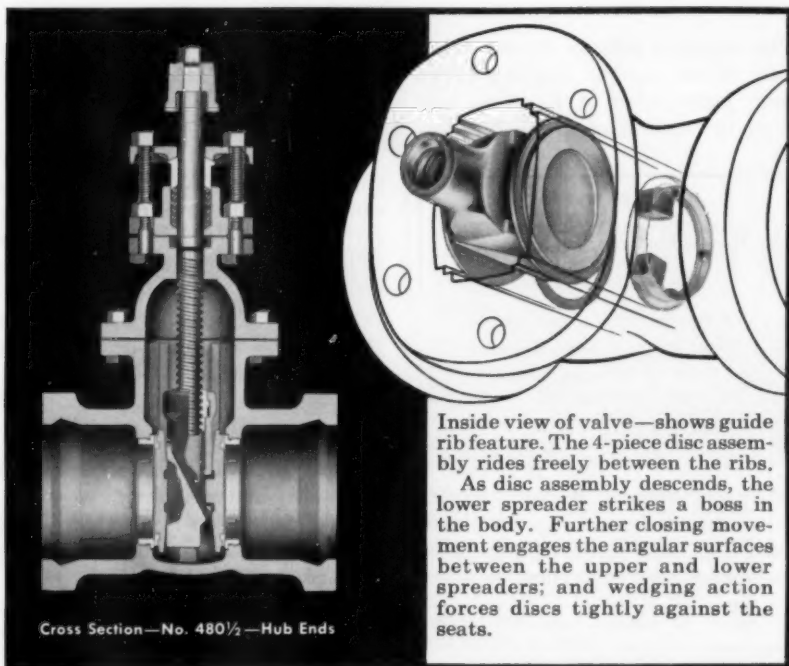
1. **Less drawdown.**
2. **Greater specific capacity.**
3. **Lowest pumping cost per million gallons of water.**

True economy is measured not by first cost alone, but in lowest yearly cost. The JOHNSON WELL SCREEN combines an unmatched record of experience and dependability with greatest strength and durability. It is the finest and most truly economical well screen in the world.

**EDWARD E. JOHNSON, INC.**

~ well screen specialists since 1904 ~  
St. Paul 4, Minn.





## Free-to-rotate discs reduce wear in new Crane AWWA Valves

Double discs that rotate freely to prevent concentrated disc and seat wear—plus an exclusive disc guiding design that assures good alignment for maximum efficiency—are just two features of the new Crane AWWA double disc, parallel seat gate valves.

The simple, foolproof, four-piece disc and spreader unit is easily assembled and will not disengage in service—discs are identical and interchangeable. Famous Crane two-piece gland and gland flange with ball-type joint protect against stem binding. These valves conform to all AWWA specifications.

These iron body, brass-trimmed gate valves have non-rising stems, and are available in 2", 3", 4", 6", 8", 10" and 12" sizes. Write for completely descriptive folder. For larger sizes, see your Crane catalog.

**CRANE VALVES & FITTINGS**  
PIPE • KITCHENS • PLUMBING • HEATING

Since 1855—Crane Co., General Offices: Chicago 5 • Branches and Wholesalers in All Areas



No. 2485—  
Flanged Ends



No. 2487 1/2—  
Mechanical  
Joint Ends

(Continued from page 44 P&amp;R)

The water in politics report of last month missed one of Election Day's highest lights when it failed to take note of the success of Philip F. Mor-

<b>VOTE FOR</b>	
<b>P. F. "Honest Phil" Morgan</b>	<input checked="" type="checkbox"/>
(R)	
Fearless — Catalytic	
A Vote for Phil is a Vote for	
Higher Wages — Lower Taxes	
Full Parity — The Iowa Turnpike	
And Everything Else	

gan, University of Iowa professor of sanitary engineering, in his campaign for the office of Iowa City councilman. Talked into running by a group of his friends who were concerned with pre-

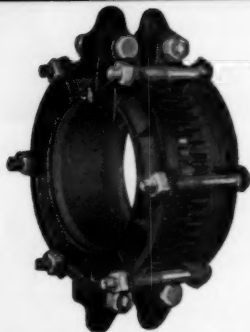
serving a newly established reform administration, the professor didn't slow down until he had paced his ticket to a runaway victory. In the race, of course, he received all kinds of support from his fellow AWWAers on and off campus, but the kind illustrated above fortunately didn't get into the hands of the opposition, so Fearless Fil was never called upon to explain that "catalytic" did not mean "reactionary Republican" and that, despite "everything else," he really was agin' sin.

To Iowa City and to Peerless Fil, our congratulations!

**Jack L. Staunton**, chief sanitary, hydraulic, and petroleum engineer of Seelye Stevenson Value & Knecht, Cons. Engrs., has been made an associate of the firm.

(Continued on page 82 P&amp;R)

## FOR REPAIRING BROKEN MAINS

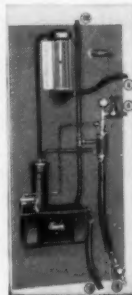


Skinner Seal Split Coupling Clamp. One man can install in 5 to 15 minutes. Gasket sealed by Monel band. Tested to 800 lbs. line pressure. A lasting repair. 2"-24" inclusive. Write today for new catalog.

**M. B. SKINNER CO.**  
SOUTH BEND 21, INDIANA, U.S.A.

## Sterelators by Everson

CHLORINE GAS CONTROL  
EQUIPMENT  
VISIBLE FLOW INDICATION  
VACUUM SOLUTION FEED  
FOR  
WATER WORKS



SEWAGE  
TREATMENT  
INDUSTRIAL  
PLANTS  
SWIMMING POOLS  
LOW COST  
COMPACT  
STURDY  
ANYONE CAN  
INSTALL  
EASY TO OPERATE  
LOW MAINTENANCE  
COSTS

WRITE FOR STERELATOR BULLETINS

**EVERSON MFG. CORP.**

221 W. HURON ST. CHICAGO 10, ILL.

# Roberts Filter

*means...*

## MUNICIPAL WATER PURIFICATION



The combined capacity of Roberts-equipped filtration plants is well over 5 billion gallons (5,000,000,000) per day. Regardless of the size of the plant or the nature of the filtration problem, Roberts Filter can be depended upon for equipment that is reliable in years of service.

## INDUSTRIAL WATER RECTIFICATION



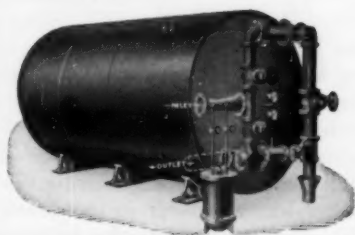
Water treatment has long been a specialty of Roberts Filter. Zeolite water softeners are guaranteed to meet all requirements for which recommended, and are available in a wide range of capacities. Roberts water conditioning equipment is widely used to control precisely the desired chemical content of water for industrial use.

## SWIMMING POOL RECIRCULATING SYSTEMS



The combination of thoroughly clarified water and efficient recirculation are features for which Roberts pools are famous. Systems for both outdoor and indoor pools are designed and installed by men long experienced in the conditions peculiar to a successful swimming pool installation.

## PRESSURE FILTERS



Closed pressure filters have wide usage where gravity filters are not justified. Roberts vertical filters are available in standard types from 12" to 96" diameter; horizontal pressure filters are all 8'0" in diameter and in varying lengths from 10'0" to 25'0".

*When you think of good water—think of Roberts Filter*

MECHANICAL EQUIPMENT  
BY  
ROBERTS FILTER MFG. CO.

# Roberts Filter

Manufacturing Company • Darby, Penna.



(Continued from page 80 P&R)

**Graduate assistantships** in sanitary engineering and sanitary science, beginning in February, June, and September 1956, are being offered by the University of North Carolina. Appointees must be eligible for admission to the graduate school and must take their major work for a master's degree in these fields. The stipend is \$1,300 per academic year (9 months); previous research experience may earn greater remuneration. Those interested should write to the Dept. of Sanitary Engineering, School of Public Health, University of North Carolina, Chapel Hill, N.C.

**John N. Chester**, founder of the consulting firm, The Chester Engineers, Pittsburgh, died at the age of 91 on Nov. 1, 1955, at Champaign, Ill., near his birthplace. Born in 1864, he was graduated from the University of Illinois in 1891. For several years he was on the engineering staff of Worthington Corp. Later he became chief engineer of what is now the American Water Works Service Co., leaving after 7 years to become general manager of Epping-Carpenter Co., Pittsburgh. In 1910 he and Thomas Fleming formed a partnership—now The Chester Engineers—to practice hydraulic and sanitary engineering. Mr. Chester was a pioneer in the development of rapid sand filtration and made some inventions in that field. He practiced in seventeen states and served as president of water companies in Pennsylvania, Ohio, and Missouri. He retired in 1937.

An AWWA member since 1910, he received the Fuller Award in 1944. He took a keen interest in engineering society matters, serving as ASCE vice-president in 1931 and 1932, and as president of the Engineers Society

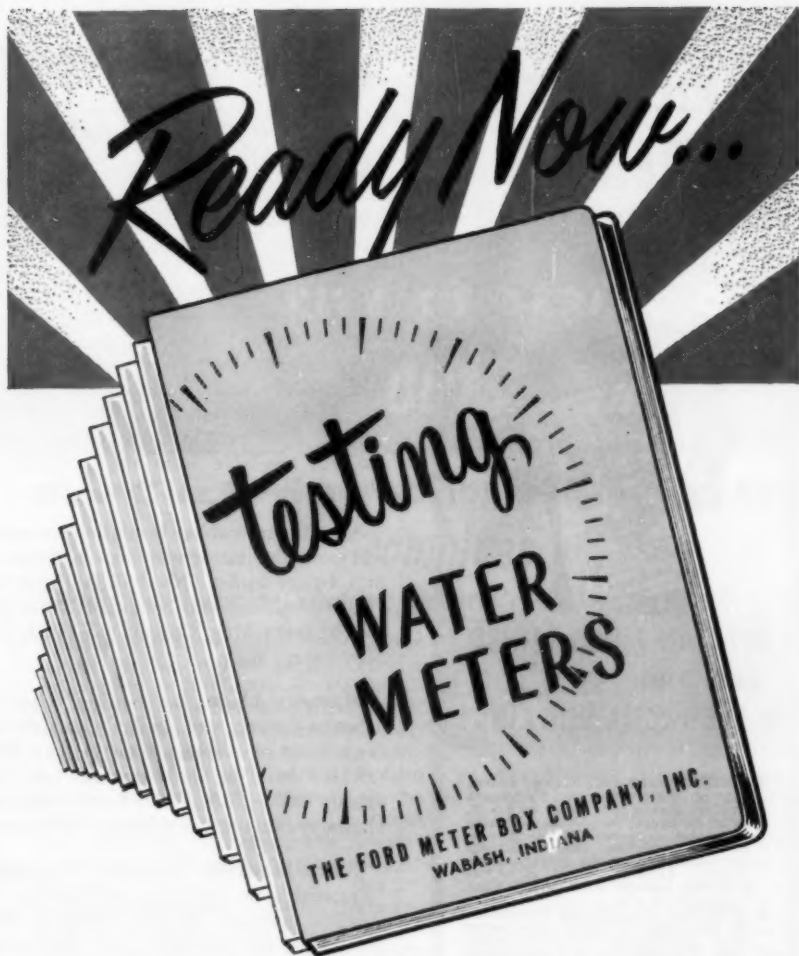
of Western Pennsylvania in 1929. He was for many years a director of the University of Illinois Foundation.

**J. Walter Ackerman**, former city manager at Watertown, N.Y., and Fall River, Mass., and an expert on municipal water supply, died Nov. 24 at Oneida, N.Y., at the age of 87. His residence was in nearby Munnsville. A graduate of Cornell University (1897), he served as city engineer at Auburn, N.Y., from 1902 to 1908, later becoming superintendent of the water board. In 1920 he accepted a similar position at Watertown and was named city manager there in 1922 and at Fall River in 1932. He was chief engineer of the Utica (N.Y.) Board of Water Supply when he retired in 1940.

Mr. Ackerman joined AWWA in 1910 and was long one of the most active and popular members of the New York Section, serving as chairman, trustee, and director. He was made an Honorary Member in 1941. Other organizations to which he belonged include ASCE and NEWWA.

**Gerald G. Lipke**, sales manager for standard products, Hagan Corp., Pittsburgh, and his wife, Patricia Wright Lipke, were among the 44 persons killed in the explosion and crash of an airliner in Colorado, Nov. 1, 1955. Mr. Lipke, 41, had been with the firm since 1936 and was named sales manager in 1954.

**Benjamin E. Cave** has been made a partner in the consulting engineer firm of Clark & Groff, Salem, Ore., with which he has been associated for 2 years. The firm name has been changed to Clark, Groff & Cave.



This 40 page book gives useful information, charts, data and instructions on water meter testing. Should be in every meter shop. Available on request without charge or obligation.

**SEND FOR YOUR COPY**

THE FORD METER BOX COMPANY, INC.  
WABASH, INDIANA

**FOR BETTER WATER SERVICES**



## DRILL WITH SPINKS

FOR HIGHER CAPACITY WELLS



### SPECIAL MUDS MINED AND PROCESSED FOR WATER WELL DRILLING!

- **SPINKS Gleason**—easy-mixing; washes out of water bearing formations quickly! Makes heavy mud in 9.5 lb. to 10 lb. range; stops unconsolidated formation cave-ins! Excellent lubrication properties; proper viscosity for removing cuttings quickly, thoroughly! Durably sacked in water-repellent asphalt lined bags! Convenient 50 lb. size.
- **SPINK-Gel**—high yielding, finest quality Wyoming bentonite. Low water loss! Exceptional lubricating qualities! Requires little to make viscous mud that floats cuttings.
- **SPINK-O**—medium weight mud, low filter loss! Combines outstanding qualities of Gleason and Spink-Gel. Get the job done quicker . . . more economically with Spinks!

*Distributorships now open  
in several choice territories*

#### H. C. SPINKS CLAY COMPANY, INC.

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Phoness 1502 and 1503  
First National Bank Bldg., Cincinnati 2, Ohio  
Phone MAIN 1-6155  
2149 East 27th St., Vernon 58, California  
Phone ADams 2-8681  
Please Contact Our Nearest Office

**HC** The Quality Brand **HC**



## Service Lines

An impact type head meter (differential producer), the "Gentile Flow Tube," is described in an illustrated brochure (Bul. FT) available from Foster Eng. Co., 835 Lehigh Ave., Union, N.J.

A sluice gate seating on a sill flush with the invert is being marketed by Rodney Hunt Machine Co. The "HY-Q" gate is described in a 12-page catalog, No. 75, available from the company at Orange, Mass.

All-silicone-rubber insulation for motor and generator stator windings is discussed in a 4-page leaflet (No. 05R8341) on the "Silco-Flex" system, obtainable from Allis-Chalmers Mfg. Co., 1026 S. 70th St., Milwaukee, Wis.

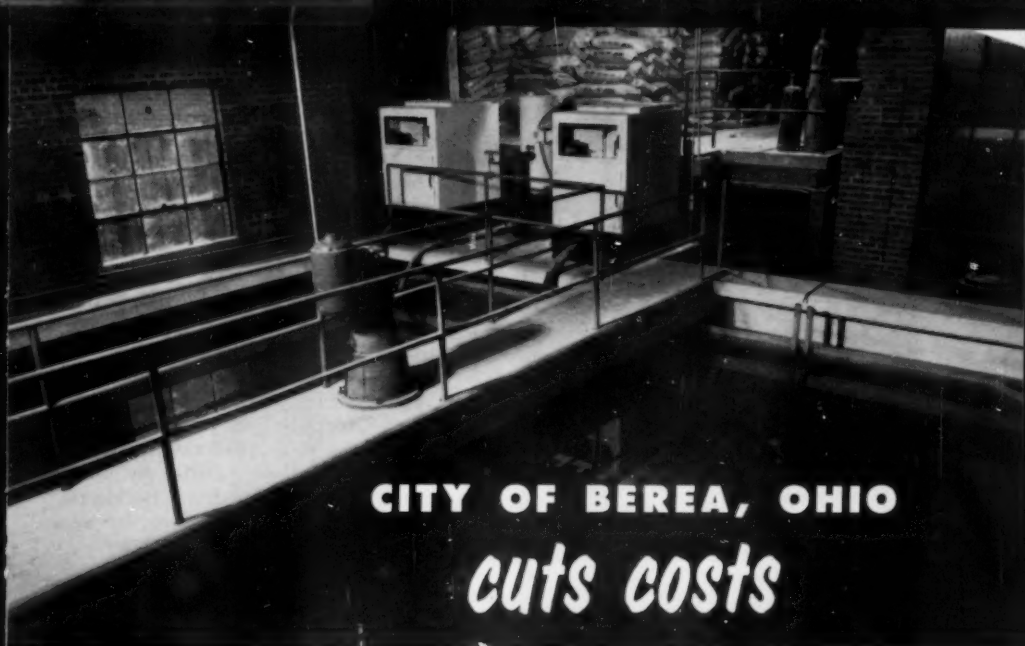
Masonry blades for cutting concrete, asbestos-cement, and similar materials are the subject of a 4-page bulletin (A-1308) released by The Carborundum Co., Niagara Falls, N.Y., which markets the blades under the trade name, "Niagara."

Johns-Manville products, including "Transite" pipe, packings and gaskets, insulating material, "Celite" diatomite filter aids, synthetic silicates, and others, are covered in a 52-page "Products Handbook" available from the company at 22 E. 40th St., New York 16, N.Y.

Flotation units for solids removal are illustrated and described in a 20-page bulletin available from the manufacturer, F. S. Gibbs, Inc., Newton 62, Mass.

Builders-Providence division of B-I-F Industries, Inc., has issued a number of new 4-page bulletins: No. 700-M1 covers Wheeler filter bottoms, precast and mono-

(Continued on page 86 P&R)



## CITY OF BEREA, OHIO *cuts costs*

### **New Cochrane SOLIDS-CONTACT REACTOR** *combines*

***mixing, precipitation, sludge concentration, clarification & softening***

The relatively hard, turbid Rocky River supply for the city of Berea, Ohio, is quickly reduced in hardness to approximately 3.5 gr/gal and to a turbidity of less than 10 ppm by the Cochrane Solids-Contact Reactor shown above. An existing concrete basin 28' square x 15' deep was modernized by conversion to the Solids-Contact type. Using hydrated lime, soda ash and alum, the Reactor treats over 2,000,000 gpd at surprisingly low cost.

Because the design of the Cochrane Reactor provides higher quality treated water faster, in less space, with minimum

chemicals, their use has grown tremendously for municipal applications. High slurry strength in the reaction zone speeds precipitation—there is very little waste water. Automatic desludging saves time and labor. In addition to softening and clarification, Cochrane Reactors remove color, taste, odor; reduce alkalinity, silica, fluorides, etc.

Cochrane's background in water conditioning makes possible the installation of complete systems under a single responsibility for continued, consistent performance. Write for Publication 5001-A and case history reprints.

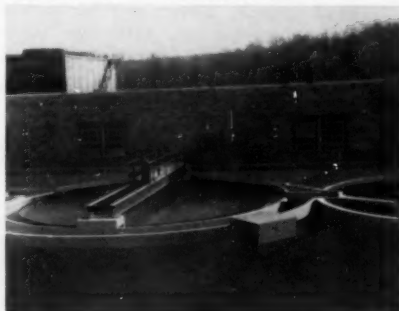


## **Cochrane** CORPORATION

3124 N. 17TH STREET, PHILADELPHIA 32, PA.  
NEW YORK • PHILADELPHIA • CHICAGO

Representatives in 30 principal cities in U.S.; Toronto, Canada; Paris, France; Mexico City, Mexico; La Spezia, Italy; Havana, Cuba; Caracas, Venezuela; San Juan, Puerto Rico; Honolulu, Hawaii; Malmo, Sweden; Santiago, Chile. **Pottstown Metal Products Division**—Custom built carbon steel and alloy products.

Cochrane also manufactures circular reactors

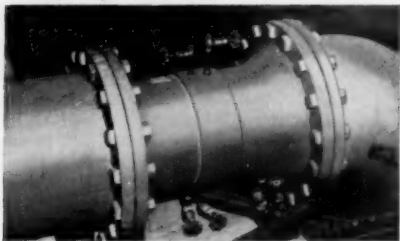


**Demineralizers • Hot Process Softeners • Hot Zeolite Softeners • Dealkalizers • Reactors  
Deaerators • Continuous Blowoff • Condensate Return Systems • Specialties**

## PIPING LAYOUT IS SIMPLER



...they need so little room



\*GEN-TIL-LY

Gentile Flow Tubes are short. They need only minimum straight runs entering and following, and can be installed at practically any accessible point where flow conditions are reasonably steady.

Flow Tubes are furnished with individual head capacity curves—and for unusual piping arrangements, calibration curves for simulated conditions can be furnished.

**Guaranteed Accuracy • Reproducibility**  
**Minimum Head Loss**

### FOSTER ENGINEERING COMPANY

835 LEHIGH AVENUE

UNION, N. J.

**AUTOMATIC VALVES • CONTROL VALVES**  
**SAFETY VALVES • FLOW TUBES**

### Service Lines

(Continued from page 84 P&R)

lithic types; No. 480-L1A, centralized filter operation and automatic backwashing with the "Auto-Central Filter Control System"; No. 650-L1B, rubber-seated butterfly valves and accessories; No. 600-J9A, power-actuated rate-of-flow controllers; and No. 840-K16, semiautomatic and step control methods of chlorine feeding. Requests for these bulletins, by number, should be addressed to Builders-Providence, Inc., 345 Harris Ave., Providence, R.I.

**Laboratory glassware** washing with Labline's mobile, power-operated washer, the "Power-Scrub," is said to be both fast and economical. The equipment is described in a 4-page brochure, No. 9100, available from Labline, Inc., 3070 W. Grand Ave., Chicago 22, Ill.

**Vertical turbine pumps**, trade-named "Verti-Line," are described in detail in an 8-page folder, Bul. 100, issued by Layne & Bowler Pump Co., 2943 Vail Ave., Los Angeles 22, Calif.

**General Filter Co.** services and equipment are depicted in a 16-page brochure entitled "Better Water." The company's headquarters are at 923—2nd St., Ames, Iowa.

**Cubicle installation** of control instruments for water conditioning plants is the subject of an illustrated 8-page bulletin (No. 4178) available from The Permutit Co., 330 W. 42nd St., New York 36, N.Y.

**Steel Structures Painting Bulletin**, a new periodical published by the Steel Structures Painting Council, is available on request from that organization. Those desiring to be placed on the mailing list should submit their names to the Council, at 4400 Fifth Ave., Pittsburgh 13, Pa. (Note: Recipients of copies of the first issue are requested to notify the Council if they desire to receive future issues. Otherwise their names will not be retained on the list.)

Consulting Engineer L. W. Veigel

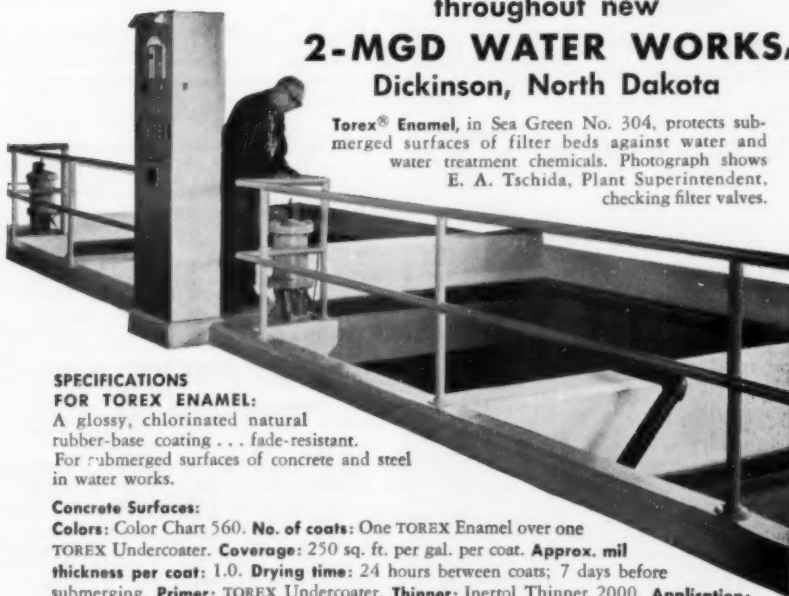
SPECIFIES

# INERTOL® COATINGS

throughout new

**2-MGD WATER WORKS,  
Dickinson, North Dakota**

**Torex® Enamel**, in Sea Green No. 304, protects submerged surfaces of filter beds against water and water treatment chemicals. Photograph shows E. A. Tschida, Plant Superintendent, checking filter valves.



## SPECIFICATIONS FOR TOREX ENAMEL:

A glossy, chlorinated natural rubber-base coating . . . fade-resistant. For submerged surfaces of concrete and steel in water works.

### Concrete Surfaces:

**Colors:** Color Chart 560. **No. of coats:** One TOREX Enamel over one TOREX Undercoater. **Coverage:** 250 sq. ft. per gal. per coat. **Approx. mil thickness per coat:** 1.0. **Drying time:** 24 hours between coats; 7 days before submerging. **Primer:** TOREX Undercoater. **Thinner:** Inertol Thinner 2000. **Application:** Apply to etched concrete. **Brushing:** As furnished. **Spraying:** Add sufficient Inertol Thinner 2000 (10 to 50%). (Write for TOREX steel-surface painting specifications.)

● In addition to TOREX ENAMEL, Consulting Engineer Veigel specified: colorful RAMUC® UTILITY ENAMEL, chlorinated natural rubber-base, for nonsubmerged masonry; GLAMORTEX® ENAMEL, mar-resistant alkyd, for nonsubmerged metal to be painted in color; INERTOL No. 49 Thick, long-wearing asphaltic coating, for submerged metal where black bituminous paint is suitable.

Inertol coatings have met the requirements of hardness, elasticity and chemical inertness in water works throughout the country. That's why Mr. Veigel chose them for the city of Dickinson, a growing farm and mining community with a prosperous future.

Buy Inertol paints direct from the manufacturer. Shipment within three days from our plant, or from nearby warehouse stocks. For full information about Inertol coatings, write today for free "Painting Guide."

Ask about Rustarmor®, Inertol's new hygroscopically controlled rust-neutralizing paint.



## INERTOL CO., INC.

A COMPLETE LINE OF QUALITY COATINGS FOR SEWAGE PLANTS & WATER WORKS

484 Frelinghuysen Avenue  
Newark 5, New Jersey

27 G South Park  
San Francisco 7, California





## NEW MEMBERS

Applications received Nov. 1-30, 1955

- Abbey, R. C.**, City Clerk, Box 218, Pascagoula, Miss. (Oct. '55)
- Alton, Bert K.**, Field Supt., Los Angeles Dept. of Water & Power, 950—1st St., San Pedro, Calif. (Oct. '55) *M*
- Anderson, Glade**, Sales Repr., Pacific States Cast Iron Pipe Co., 6399 Wilshire Blvd., Los Angeles 48, Calif. (Oct. '55) *D*
- Baker, Robert C.**, Sales Engr., Rockwell Mfg. Co., Apt. 1, 3126 Stuart Ave., Richmond 21, Va. (Oct. '55)
- Barbarossa, Gordon F.**, Pres., Barbarossa & Sons Inc., 402—33rd Ave. N., St. Cloud, Minn. (Oct. '55)
- Bell, Philip B., Jr.**, Asst. Supt. of Utilities, Box 477, Springfield, Tenn. (Oct. '55) *M*
- Bergeron, Jean Louis**, Supt., Filtration Plant, 143 Caroline St., Longueuil, Que. (Oct. '55)
- Bradley, Henry H.**, Field Engr., Fairbanks, Morse & Co., 69 N.E. 48th St., Miami, Fla. (Oct. '55) *MRPD*
- Brecka, John A.**, Supt., Water & Sewers, 723 Excelsior Ave., Hopkins, Minn. (Oct. '55) *P*
- Burbridge, Carl S.**, Utilities Mgr., Pompano Beach Highlands Water & Sewer Dept., 8 Mackle Shopping Center, Pompano Beach, Fla. (Oct. '55) *MD*
- Canajoharie, Village of**, Donald G. Hill, Chief Operator, Filter Plant, Moyer St., Canajoharie, N.Y. (Munic. Sv. Sub. Oct. '55) *MPD*
- Chevallier, Charles R., Jr.**, Director of Public Works, City Hall, Delray Beach, Fla. (Oct. '55) *MPD*
- Clecro, Town of, Water Dept.**, Walter H. Maine, Gen. Supt., Box 43, Brewerton, N.Y. (Munic. Sv. Sub. Oct. '55) *M*
- Cochran, D. B.**, Sales Repr., Johns-Manville Corp., Box 2251, Spring Hill, Ala. (Oct. '55) *D*
- Coffey, R. A.**, Operator & Chemist, Water Works Board, Bridgeport, Ala. (Oct. '55) *PD*
- Dallas, Russell**, Director, Utility Dept., Sanford, Fla. (Oct. '55) *D*
- Devenney, William F.**, Cons. Engr., E. I. du Pont de Nemours & Co., Inc., Wilmington 98, Del. (Oct. '55) *P*
- Donohoe, John B.**, Sales Engr., A. P. Smith Mfg. Co., Box 582, Springfield, Mass. (Oct. '55)
- Duvall, Sam E.**, Sales Engr., Sanfax Co., 723 Bennett St., Greenville, S.C. (Oct. '55) *D*
- Ezell, H. C.**, Supt., Public Works, Box 218, Pascagoula, Miss. (Oct. '55)
- Farmer, Howard N., Jr.**, Tech. Repr., International Nickel Co., Inc., 714 W. Olympic Blvd., Los Angeles, Calif. (Oct. '55) *D*
- Friedgen, Robert D.**, Civ. Engr., La Mesa, Spring Valley & Lemon Grove Irrigation Dist., 4769 Spring St., La Mesa, Calif. (Oct. '55) *D*
- Fuller, Jack H.**, Cons. Civ. Engr., 202 Wooster Pike, Milford, Ohio (Oct. '55) *RD*
- Graham, W. F.**, Asst. Engr., R. D. Cole Mfg. Co., E. Broad St., Newnan, Ga. (Oct. '55) *D*
- Hentley, George W.**, Asst. Supt., Div. of Water, City Hall, 1685 Main St., Santa Monica, Calif. (Oct. '55) *M*
- Hill, Donald G.**; see Canajoharie (N.Y.)
- Johnston, J. E.**, Director, Div. of San. Eng., State Board of Health, Jackson, Miss. (Oct. '55) *RPD*
- Kadow, Kenneth J.**; see Turnagain Homes
- Kestner, Charles C.**, City Engr., Harrisonburg, Va. (Oct. '55) *PD*
- Ketchie, Homer R.**, Salesman, 3113 Airlie St., Charlotte 5, N.C. (Oct. '55) *P*
- Klee, George F.**, Sales Repr., US Pipe & Foundry Co., 71 Broadway, New York 6, N.Y. (Oct. '55)
- Kolln, William K.**, Sales Engr., Johns-Manville Sales Corp., Celite Div., 19 W. 38th St., Indianapolis, Ind. (Oct. '55)
- Maine, Walter H.**; see Cicero (N.Y.) Water Dept.
- McClintick, James H.**, Sales Repr., Mueller Co., 906 Reinthaler Dr., Bloomington, Ill. (Oct. '55)
- McDonald, James W.**, Supt., Thermo-Irrigation Dist., Rte. 3, Box 1113, Oroville, Calif. (Oct. '55) *MPD*
- McKinley, R. J.**, Water Comr., Phillipsburg, Mont. (Oct. '55) *MRP*
- McLean, Edward F.**, Engr., Water Dept., 1815—16th Ave., Meridian, Miss. (Oct. '55) *P*
- New Highway Water Works Co. Inc.**, Sidney N. Weniger, Pres., 62—3rd Ave., Mineola, N.Y. (Corp. M. Oct. '55) *M*
- Ohlson, Earl G.**, Purchasing Agent, American Water Works Service Co., Inc., 3 Penn Center Plaza, Philadelphia 2, Pa. (Oct. '55)
- Onodera, Ben**, San. Eng. Asst., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '55) *RPD*
- Patterson, R. N.**, Sales Engr., R. N. Patterson Co., 2553 Vail Ave., Charlotte, N.C. (Oct. '55)
- Peele, Walter E.**, Supt. of Plants, Fort Lauderdale, Fla. (Oct. '55) *P*
- Pettit, W. Lee**, Supt., Water & Sewer Dept., 807 W. 6th St., Weslaco, Tex. (Oct. '55) *MD*
- Phelps, Boyd William**, Design Engr., Boyd E. Phelps, Inc., 1000 Washington St., Michigan City, Ind. (Oct. '55) *RPD*
- Pickett, Hubert W., Jr.**, Engr., Water & Sewer Dept., Durham, N.C. (Oct. '55) *MD*
- Pilzer, John E.**, Asst. Supt. of Operations, Gary-Hobart Water Corp., 650 Madison St., Gary, Ind. (Oct. '55) *D*
- Pittenger, Robert A.**, Asst. Supt., Middlesex Water Co., 52 Main St., Woodbridge, N.J. (Oct. '55) *M*
- Plowman, Herbert, Jr.**, Chemist, Gary-Hobart Water Corp., 650 Madison St., Gary, Ind. (Oct. '55) *P*
- Porter, M. A.**, Sr. Exec. Engr., Public Works Dept., Selanger, Victory Ave., Kuala Lumpur, Malaya (Oct. '55) *MRPD*
- Prescott, Harold S.**, Cons. Engr., 594 Main St., Placerville, Calif. (Oct. '55) *RP*
- Rambo, David**, Supt., Public Works, 601 N. Main St., Porterville, Calif. (Oct. '55) *RD*
- Reghi, John**, Foreman, Water Dept., 19617 Harper Ave., Harper Woods 36, Mich. (Oct. '55) *M*
- Robb, Robert D.**, Longview Lime Corp., 4226 Palmer Ave., Jacksonville, Fla. (Oct. '55) *P*
- Robinson, Jesse S.**, Water Works Engr., City Hall, Fresno, Calif. (Oct. '55) *MRPD*
- Rowe, Rollin V.**, Regional Sales Mgr., Byron Jackson Div., Borg-Warner Corp., 719 K St., Sacramento 14, Calif. (Oct. '55) *D*
- Ruddy, Brian**, Township Engr., Township of Pickering, Munic. Office, Brougham, Ont. (Oct. '55)
- Russell, Earl W.**, Acting Supt., Filtration Plant, City Hall, Painesville, Ohio (Oct. '55) *M*
- Russell, Robert C.**, Engr., J. W. Goodwin Eng. Co., Inc., 2111—7th Ave. S., Birmingham, Ala. (Oct. '55) *RPD*
- Ryan, Christopher J.**, Water Registrar, Box 567, Allendale, N.J. (Oct. '55) *D*
- Saarinne, Arthur W., Jr.**, Cons. Engr., Philpott, Ross & Saarinne, 1016 N.E. 7th Ave., Fort Lauderdale, Fla. (Oct. '55) *MRPD*
- Sackowitz, Isidore**, Supt., Public Works, Roosevelt, N.J. (Oct. '55) *MRPD*
- Sanders, Carroll A.**, Tech. Supervisor, Reliance Chemicals Corp., Box 6724, Houston 5, Tex. (Oct. '55) *M*
- Savinell, Emilio A.**, Research Assoc., State Water Survey, Urbana, Ill. (Oct. '55) *RP*
- Schroeder, Edwin F.**, Water Works Supt., Munic. Utilities, Box 135, Kenyon, Minn. (Oct. '55) *M*
- Scott, Samuel J.**, Supt., Water Dept., City Hall, 33 Delaware St., Woodbury, N.J. (Oct. '55) *MRPD*

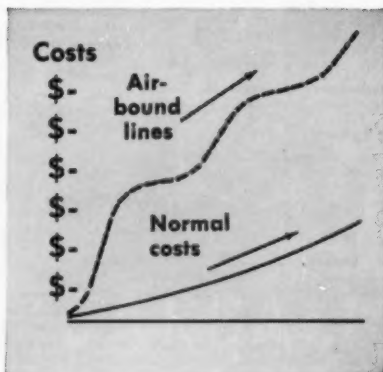
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- Sears, Homer T.**, 908 N. Highland Ave., N.E., Atlanta, Ga. (Oct. '55)
- Sellers, Floyd W.**, Supt., Water Dept., Northfield, Minn. (Oct. '55) *M*
- Shaw, Harold**, Engr., Salyer Land Co. & Salyer Water Dist., Box 488, Corcoran, Calif. (Oct. '55) *MRPD*
- Shellenberger, Richard D.**, Tech. Service Repr., Indus. Chem. Sales Div., West Virginia Pulp & Paper Co., Tyrone, Pa. (Oct. '55) *P*
- Shocum, Gerald W.**, Salesman, Homelite Corp., 418 W. 6th St., Rochester, Ind. (Oct. '55)
- Shull, W. G.**, Office Engr., Howard Lee Cromer, Box 133, Delray Beach, Fla. (Oct. '55) *MD*
- Silver, Lessing L.**, Water Chem. Engr., South Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago, Ill. (Jr. M. Oct. '55)
- Slocumb, Joe W.**, Maint. Supervisor, Div. of Water, Rm. 112, City Hall, Sacramento, Calif. (Oct. '55) *D*
- Smith, Bert Page**, Engr., Whitman, Requaert & Assocs., 2 W. Preston St., Baltimore, Md. (Oct. '55) *P*
- Smith, Doyle**, Supt., Box 3, Hobart, Okla. (Oct. '55)
- Spall, William B.**, Salesman, Ulrich Chemical Inc., 2640 W. Minnesota, Indianapolis, Ind. (Oct. '55)
- Spivey, D. E.**, Supt., Water & Sewage, Jacksonville, Tex. (Oct. '55) *MP*
- Squires, Norman H.**, Distr. Supervisor, Div. of Water, 3201 S St., Sacramento, Calif. (Oct. '55) *D*
- Stearns, Whitney K.**, Sales Repr., US Pipe & Foundry Co., 71 Broadway, New York 6, N.Y. (Oct. '55) *D*
- Stewart, Douglas H.**, Cons. Engr., Thief River Falls, Minn. (Oct. '55) *MP*
- Sushko, Walter C.**, Forester, Watersheds, Bureau of Water Supply, 500 Municipal Bldg., Baltimore 2, Md. (Oct. '55) *R*
- Thacker, Henry R.**, Graduate Student, Dept. of Civ. Engr., Virginia Polytechnic Inst., 1112 Kentwood Dr., Blacksburg, Va. (Oct. '55)
- Tomme, E. M.**, Director of Public Works, 494 W. Main Ave., Raymondville, Tex. (Oct. '55)
- Tools, Jerry F.**, Chemist, Dept. of Water & Sewage, Miami, Fla. (Oct. '55) *P*
- Trejo, Manuel J.**, Supt., Water & Sewers, Box 185, Premont, Tex. (Oct. '55) *P*
- Turnagain Homes Inc.**, Kenneth J. Kadow, Vice-Pres. & Mgr., Box 1566, Anchorage, Alaska (Corp. M. Oct. '55) *MD*
- Twomley, Donald L.**, Supt., Southern California Water Co., 7045 Palm Ave., Highland, Calif. (Oct. '55) *PD*
- Van Frank, Fred H.**, San. Eng. Asst., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '55) *RPD*
- Vieira, Mario Ramos**, Civ. Engr., Empresa Brasileira de Engenharia S.A., Rua Santa Luzia 685, Caixa Postal 96, Rio de Janeiro, Brazil (Oct. '55) *MRPD*
- Voegtli, Thomas V.**, Sales Repr., B-I-F Industries, Inc., 605 Sexton Bldg., Minneapolis, Minn. (Oct. '55) *P*
- Walker, Lawrence G.**, Sales Repr., Davis Meter Repair & Supply Co., Dania, Fla. (Oct. '55)
- Ward, Thomas R.**, Sales Engr., Rockwell Mfg. Co., 222 S. Church St., Charlotte 2, N.C. (Oct. '55)
- Warkentin, E. C.**, Regional Engr., Dept. of Health, Education, & Welfare, Public Health Service, 1114 Commerce St., Dallas, Tex. (Oct. '55) *R*
- Watson, Leslie J.**, Head, Water Resources Div., Board of Water Supply, Box 3410, Honolulu, Hawaii (Oct. '55) *MR*
- Webber, R. B.**, Sales Engr., L. E. Shaw, Ltd., 74 Bedford Row, Halifax, N.S. (Oct. '55)
- Weber, Leon**, Research Chemist, Shell Development Co., Exploration & Production Research Div., 3737 Bellaire Blvd., Houston 25, Tex. (Oct. '55) *RP*
- Wefling, Del F.**, Engr., Water Board, San Antonio, Tex. (Oct. '55) *M*
- Weniger, Sidney N.**; see New Highway Water Works Co.
- Westbay, A. W.**, Asst. Supt., Water Dept., Amarillo, Tex. (Oct. '55) *M*
- Whiddon, E. L.**, Supt., Willowbend Utilities, 10500 Cliffwood, Bellaire, Tex. (Oct. '55)
- Whitmore, Donald C.**, Supt., Water & Sewer Dept., Clinton Township, Macomb County, Mich. (Oct. '55) *MD*
- Wiggins, W. Ed**, Mayor, Box 218, Pascagoula, Miss. (Oct. '55)
- Williams, J. S.**, Vice-Pres., J. L. Williams Constr. Co., Inc., Box 164, Bellaire, Tex. (Oct. '55) *M*
- Williams, Robert J.**, Salesman, Layne-Northern, 1041 Riverside Dr., South Bend, Ind. (Oct. '55) *R*
- Wilson, Homer**, Mgr., Water & Sewer Systems, Hondo, Tex. (Oct. '55) *M*
- Winiger, Caspar L.**, Supervisor, Water Div., Dept. of Public Works, City Hall, Santa Monica, Calif. (Oct. '55) *M*
- Yawn, B. Hal**, Salesman, John-Manville Corp., Transite Pipe Div., 3619 E. Tampa Circle, Tampa, Fla. (Oct. '55) *D*
- Yee, Joe F.**, Assoc. Engr., Div. of Water, Rm. 112, City Hall, Sacramento, Calif. (Oct. '55) *M*
- York, Jack T.**, Repr., Southern Meter & Repair Co., Box 887, Marshall, Tex. (Oct. '55)
- Ziemke, Norman R.**, Research Fellow, Univ. of Minn., 9068 Van Buren St. N.E., Minneapolis 34, Minn. (Jr. M. Oct. '55)

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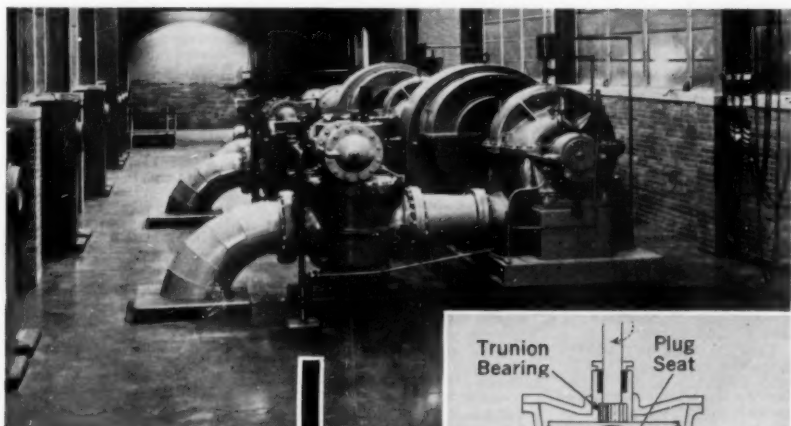
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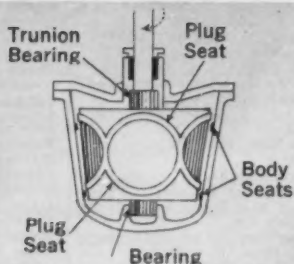
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Industries)

Wallace &amp; Tiernan Inc.

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American Well Works

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Morse Bros. Mch. Co.

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Jos. G. Pollard Co., Inc.

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**Pumps, Sump:**

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**Recorders, Gas Density, CO<sub>2</sub>,**NH<sub>3</sub>, SO<sub>2</sub>, etc.,

Fischer &amp; Porter Co.

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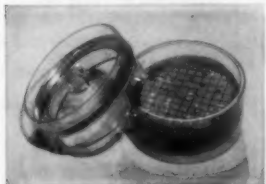
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The FIELD MONITOR pre-sterilized closed system, and equipment shown, represents everything required for critical microbiological procedures. Samples may be shipped to laboratory or incubated in the field.



**FIELD INCUBATOR** functions on  
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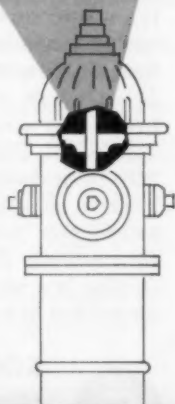
**Zeolite; see Ion Exchange****Materials**

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1955 AWWA Directory.



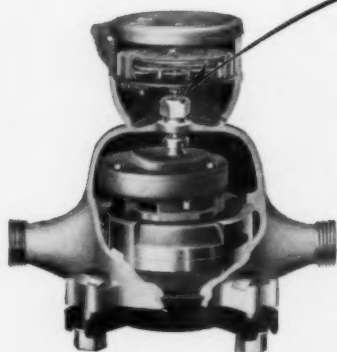
M & H Hydrants can be furnished with Rubber O-Rings Seals if desired. The Seal Plate and O-Rings replace the conventional design of stuffing box, gland and packing. O-Ring Seal Plates can also be supplied for hydrants in service.

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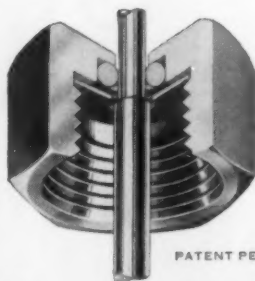
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# The Rockwell "O"-Ring Stuffing Box Assembly



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*Stops Leaks, Binds,  
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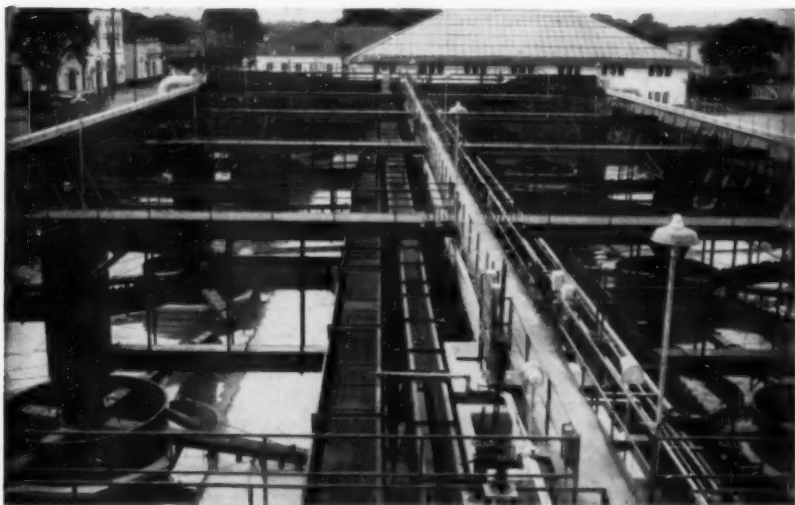
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*you won't find identical twins*

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***Gets Immediate Softening and Clarification Capacity While Long Range Improvements are Made***

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